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DIATOMS OF THE MORENO SHALE

JOHN A. LONG,[1] DINGLEY P. FUGE[2] AND JAMES SMITH[3]

ABSTRACT—The latest definitely identified Cretaceous formation in California is a thick body of very distinctive shale, the Moreno formation, which outcrops in the San Joaquin Valley for a distance of 150 miles. It contains residual hydrocarbons in considerable amount. Megafossils are scarce, but certain zones contain incredible numbers of microfossils belonging to several groups. Those which have skeletons of silica have been studied more thoroughly than the calcareous forms and the present paper is the result of an exhaustive search of many samples for diatoms. A review of the literature which has dealt with any phase of the paleontology of the formation is included and this indicates that the Moreno is now the best known of any part of the California Cretaceous. A striking discovery in recent years was the finding of well-preserved skeletons of large reptiles such as plesiosaurs. The introduction contains information pertaining to the geological relationships, geographical extent and some of the physical aspects of the formation.

INTRODUCTION

Notes on the geology and general paleontology of the Moreno Shale

G. Dallas Hanna
California Academy of Sciences

THE MORENO Shale is a well defined Upper Cretaceous stratigraphic unit extending along the west side of the San Joaquin valley, California, from Mount Diablo on the north nearly to Coalinga on the south. Beyond the southernmost exposures it has been identified in well sections as far as McLure Valley where the Tidewater Associated Oil Company cored over 100 feet of the upper part of the formation in West Slope well No. 1, Sec. 20, T. 24 S., R. 18 E., M.D.M., Kings County. It has been identified in wells a short distance outward from the outcrops but it dips steeply under the Valley and its extent in that direction is unknown. No trace of it appears on the east side along the foothills of the Sierra Nevada. Many wells in the southeast corner of the Valley have been drilled to basement without encountering it.

Lithologically, the shale is readily distinguished on outcrops as a very fine silt, generally weathering with a definitely purple tinge. Fresh exposures and well samples are usually dark chocolate brown

[1] Menston-in-Wharfedale, Leeds, England; deceased 1945.
[2] Shipley, Yorkshire, England; deceased 1944.
[3] 1725 Bushnell Avenue, South Pasadena, California.

to black, often somewhat "waxy" in texture due to a high content of residual hydrocarbon. The silts become somewhat coarser downward in the section and there is no sharp stratigraphic break at the contact with the formation below. The top of the latter, however, is usually mapped at the top of the first heavy brown sandstone member.

In some of the wells which have been drilled into and through the shale a short distance out from the margin of the Valley, the upper Moreno contact is very difficult to locate with certainty; Eocene sediments grade gradually downward into Cretaceous and the foraminiferal faunas show an intermingling in the border zone which is very puzzling.

The thickness of the Moreno is not uniform throughout its extent. In the Coalinga region careful measurements made by Messrs. J. J. Bryan and O. F. Kotick show 1100 feet. The maximum they found is in the vicinity of Ortigalito Creek where it reached over 4000 feet. Farther north it thins and then thickens again. Evidence of oil is not uncommon and one small field ("Oil City" nine miles north of Coalinga) has produced continuously from it since 1896, the first well there which showed oil having been drilled in 1890 (Arnold and Anderson, p. 180).

While the distinctiveness of the formation had been known to geologists for many years previously and some had mentioned it in print, the first broad description, map, and the name date from the work of Anderson and Pack (pp. 46–57). In selecting a type locality, they wisely chose the section exposed in Moreno Gulch, a water course cut deeply into the eastward slope of the Panoche Hills and located only about four miles north of the station which furnished the diatoms forming the subject of this report.

There is apparently a well-marked unconformity at the top of the shale in Moreno Gulch where it is overlain by a sand believed to be Martinez Eocene. At other places along the strike the immediately overlying formation varies in age from late alluvium to lower Eocene and there is a borderline zone which is very difficult to place. From 1941 to 1944 geologists attached to various oil companies have given this contact a great deal of study and general agreement as to the exact top of the Moreno has not been reached. The vertical distribution of a few species of Foraminifera and lateral variation in lithology of the contact zone have caused some of the difficulty. However, very little has been published on the subject.

Many new formation and "member" names have been proposed lately in attempts to subdivide the Moreno, but these have not appeared officially in print except in programs of geological meetings and abstracts.

In 1940 Allan Bennison submitted a thesis to the faculty of the University of California Department of Geological Sciences, in which he subdivided the Moreno north of Panoche Hills into several members. This thesis has not been published but other authors have adopted his names and some of them are in more or less current use. Several petroleum geologists who have mapped the area are inclined to believe the beds named, at least in part, are below the true Moreno as exposed and defined in Moreno Gulch and thus would not fall within the scope of the present review. However, references are cited because of the original supposition that they were Moreno. F. M. Anderson (1937, p. 1612) published the names in abstract form and A. S. Huey (p. 335) did likewise during the same year. Considerable information regarding some of the names was given in 1941 by F. M. Anderson (pp. 185–186) and by N. L. Taliaferro (pp. 132–134). The five names were listed by O. P. Jenkins in 1943.

In spite of repeated appearance of the various names in print, no proper or adequate descriptions or designations of type localities have been presented.

Max B. Payne read a paper at the April 18–19, 1941 meeting of the Cordilleran Section of The Geological Society of America, entitled "Moreno Shale, Panoche Hills, Fresno County, California," and an abstract of this appeared on page 19 of the preliminary list of titles and abstracts. Six new names were there proposed. The abstract was reprinted later in Bull. Geol. Soc. America, vol. 52, 1941, pp. 1953–1954 and from this the names were collected and published, without additional definition, by O. P. Jenkins.

This makes a total of 11 names sup-

posedly applying to the subdivision of the Moreno shale all of which have been rather indefinitely proposed. If the formation should need division it would seem that "Moreno" should be properly retained for the zone which has preserved diatoms in the Panoche Hills since this zone is the only portion which has been adequately defined paleontologically.

F. M. Anderson first mentioned fossils in the shale in 1905 (p. 193). He listed and illustrated "*Sagrina*," a foraminifer, from near Coalinga similar to *Siphogenerinoides cretacea* Cushman and now known as *Siphogenerinoides whitei* Church (Hanna, 1925, p. 992; Taff and Hanna, 1926, pp. 812–814).[4] Since then more species of various groups have been identified from the formation than from any other single Cretaceous unit in California. Cushman and Campbell in 1935 (pp. 65–73, pl. 10, 11) listed and illustrated 20 forms of Foraminifera from samples (believed at that time to be Moreno but which some workers now think is Panoche) taken from a well drilled near Tracy and a year later described *Siphogenerinoides clarki* (Cushman and Campbell, 1936, pp. 91–92, pl. 13, figs. 9–12) from outcrop samples near Mt. Diablo. The occurrence of this species (or *S. whitei*) has been mentioned in various publications usually without specific name.

In 1943 A. S. Campbell (pp. 128, 129) listed 11 species of Foraminifera from matrix shale associated with the skeleton of the plesiosaur *Hydrotherosaurus alexandrae* Wells. The locality is not far from where the diatoms were collected which form the basis of the present report but about 775 feet lower in the section.

Anderson and Pack (pp. 46, 47), in the original description of the Moreno, mentioned a zone near the top which contains large numbers of diatoms. This is a striking member, particularly when seen from above, being pure white to light buff and about 100 feet thick. G. D. Hanna (1927) undertook a study of these diatoms in 1926 and collected his material at the type locality, Moreno Gulch. The primary object of the investigation was to determine if noticeable differences in the floras were apparent between this and the much younger Kreyenhagen and Miocene ones. Not many species were found in common. Later another locality a few miles to the southward of the first was investigated briefly and eight additional forms were recorded and discussed (Hanna, 1934).

In this work it was learned that the silicoflagellates were highly characteristic and good guide fossils for the siliceous shales of various ages in California and those of the Moreno (5 species) were published in 1928 (Hanna, 1928).

Diatomists in other parts of the world were attracted by the unusual nature of many of the species described by Hanna and requests for material were promptly filled. This resulted in the discovery of additional forms not previously known, some of which have been published.

Lefébure and Chenevière described *Kittonia hannai* in 1939 from material collected in Sec. 6, T. 15 S., R. 12 E., M.D.B. & M., Fresno County, California. In 1940 Leopoldo Rampi described and illustrated 16 species (11 new) of Archaeomonadaceae from some of the shale collected by Mr. Smith in connection with work on the present paper. Rampi did not give an exact locality and since only "Moreno U.S.A." is mentioned it seems desirable to point out that his sample came from Sec. 24, T. 14 S., R. 11 E., M.D.B. & M., Fresno County, California, Moreno shale, Upper Cretaceous.

The following forms were treated:

Archaeomonas inconspicua Deflandre
semplicia Rampi
mangini Deflandre
spinulosa Rampi
chiarugii Rampi
ambigua Rampi
membranosa Rampi
scrobiculata Rampi
vermiculosa Deflandre
cretacea Rampi
heteroptera Deflandre
smithi Rampi
Archaeomonadopsis frenguellii Rampi
incerta Rampi
elegante Rampi
Archaëspaeridium dangeardianum Deflandre

[4] *S. cretacea* was formally described by J. A. Cushman (1929, p. 58, pl. 9, figs. 14, 15) from the Colon shale, Upper Cretaceous, Quebrada Honda, Venezuela. The California form was formally described as *Siphogenerinoides whitei* in 1941 from material collected very close to the exact outcrop which furnished the diatoms described in the following pages (Church, 1941, p. 182, fig. 67–37.)

In some of the sands and conglomerates north of Panoche Hills, there are large numbers of mollusks. Many of these were studied by Bennison but the identifications have not been published. The shales of the Moreno and the white calcareous concretions in them contain occasional ammonites, baculites, small pectens and *Acila;* these likewise have not been specifically identified.

Anderson and Pack, in the original description of the formation, mentioned the great abundance of microfossils but the only determinations made from their collections were the fishes *Chicolepis punctatus, Pomolobus? chicoensis, Erythrinolepis chicoensis* and *Echidnocephalus? pacificus* described as new from scales by T. D. A. Cockerell (1919).

C. L. Camp in 1942 (p. 10) mentioned the finding of two vertebrae of a fossil reptile in the Panoche Hills area by Herman G. Walker in 1918 to 1920. These apparently were the first remains of vertebrates, other than fishes to be found in the Cretaceous of California. In 1931, C. C. Church found three phalanges of a medium-sized reptile in Panoche strata a few hundred feet below the base of the Moreno shale. The locality is in Los Gatos Creek near Coalinga, Fresno County, California and the specimens are recorded as No. 7344 A-C, Calif. Acad. Sci. Type Coll. The finding of these small bones was sufficient evidence to warrant our urging Mr. Allan Bennison to search carefully near Gustine, California, where he was then a high-school student. It was not long until he had made important discoveries and it was through his early efforts that sufficient attention was attracted to the Moreno shale that well equipped exploration was subsequently undertaken by trained paleontologists. The history of the discoveries to date is given by Chester Stock (1939, see also anonymous photograph, 1939); C. L. Camp (1942) and S. P. Wells (1943).

As a result of the various activities the following mosasaurs were described in 1942: *Kolposaurus bennisoni* Camp; *Kolposaurus tuckeri* Camp; and *Plesiotylosaurus crassidens* Camp. The next year the plesiosaurs *Hydrotherosaurus alexandrae* Wells; *Morenosaurus stocki* Wells; *Aphrosaurus furlongi* Wells and *Fresnosaurus drescheri* Wells were described. Previously Hesse and Wells (1936) had announced the discovery of a duck-billed dinosaur from the Moreno but a detailed study of the fossil has not appeared. Anderson (1941b) published the new genus-name *Garzasaurus* in connection with some one of these Moreno reptiles but no diagnostic characters were given. Taliaferro (1944) has presented a resume of the geological relationships of the strata in which all of these reptiles were found.

While the manuscript of the present paper was in process of being edited and printed, there appeared another publication which deals in part with the Moreno shale (Goudkoff, 1945). This paper gives references to most of the previous work on the formation as well as those lower in the section. On fig. 2, the author gave a valuable correlation of the multitude of subdivisional names which have been proposed. He limited the Moreno proper to his own A, B and C zones, to which he applied and defined stage names "Cheneyan," "Upper Ciervian" and "Lower Ciervian" respectively.

Mr. James Smith became interested in the Moreno shale soon after the first papers on the diatoms appeared and made several collecting trips to Panoche Hills. Material in large quantity was collected. Subsequent preparation and the making of beautiful, individual mounts was carried on with enviable patience for several years. I had the good fortune to see his remarkable collection of slides after the photography was under way and was impressed by its great scientific value. Messrs. John A. Long and Dingley P. Fuge consented to undertake the taxonomic study of the collection and the following paper is the result of the work of these three men. Mr. N. Ingram Hendey of the British Museum rendered valuable assistance on numerous occasions and made the beautiful drawings which appear as figures. Being fully occupied with other duties my own connection with the investigation has been purely advisory, and this largely in regard to editorial matters.

The locality from which the collection was obtained is in the fourth eastward-flowing gulley shown on U. S. Geol. Survey Topographic Map, Panoche Quadrangle,

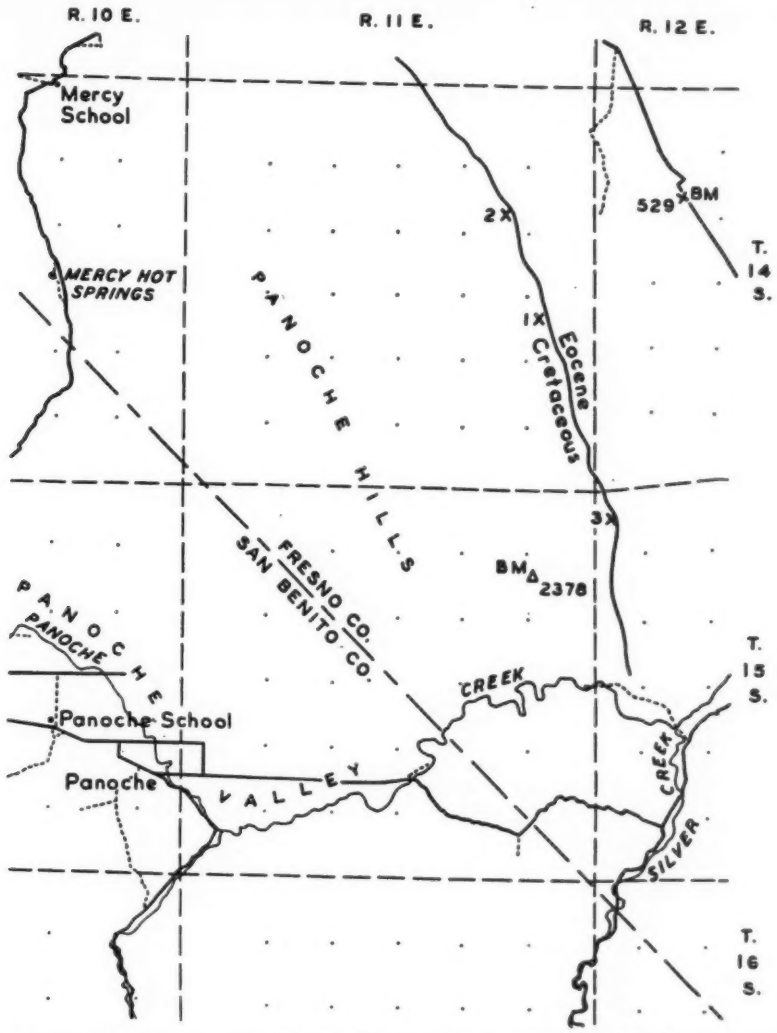


FIG. 1—Outline map from a portion of U. S. Geological Survey topographic sheet, Panoche Quadrangle, Fresno County, California, showing location of stations from which diatoms for this and preceding papers were obtained. Scale ½ inch = 1 mile. Cretaceous-Eocene boundary line approximate and adapted from map published by Anderson and Pack, U. S. Geol. Surv. Bull. 603, 1915.

1. Sec. 24, T. 14 S., R. 11 E., M. D. B. & M., from which the collections for the present study were made.

2. Sec. 11, T. 14 S., R. 11 E., M. D. B. & M., Moreno Gulch, the type locality of the Moreno formation, from which the material was obtained by Hanna, Calif. Acad. Sci. Occ. Pprs. 13, 1927, pp. 1–48, 5 pls.

3. Sec. 6, T. 15 S., R. 12 E., M. D. B & M., from which the material was obtained by Hanna, Journ. Paleo., vol. 8, no. 3, 1934, pp. 352–355, 1 pl., and Journ. Paleo., vol. 1, no. 4, 1928, pp. 259–263, 1 pl.

along the east flank of Panoche Hills, north of Panoche Creek, Sec. 24, T.14 S., R. 11 E., M.D.B. & M., western Fresno County California. The finding of so many additional species speaks well for the thoroughness of the present study but the authors would be the last to imply that the wonderful deposit is exhausted of novelties. The

map (fig. 1) shows the geographic position of the collecting station in the zone of diatomite.

The photographs of the diatoms were made by Mr. Smith and the slides have been deposited in the collection of type material in the California Academy of Sciences.

DESCRIPTIONS OF FOSSILS

John A. Long, Dingley P. Fuge and James Smith

ACTINODICTYON WEISSFLOGII UNCA, Long, Fuge and Smith, n. var.
Plate 13, figure 8

The occurrence of this rare diatom, whose typical form was reported by Pantocsek from Russia, is noteworthy.

The Moreno forms correspond closely to that illustrated by Pantocsek (1893, pl. 5, fig. 84) save that in them there is attached to each of the aulacodiscoid processes with which the clear channels terminate, a slender hook-shaped rod which is bent immediately backwards and lies along the furrow. Diameter .059 mm.

Several specimens have been observed with from five to seven channels and in each these hooks were a characteristic feature.

Holotype, No. 3345.

ACTINOPTYCHUS CHENEVIEREI Long, Fuge and Smith, n. sp.
Plate 13, figure 10

Valve circular with narrow hyaline margin and polygonal hyaline center. Sectors 10 in number, all closely beaded in decussating lines; an irregular network over the surface of each sector. The lower sectors have an indistinct pseudo-raphe and a narrow hyaline line near the circumference; the upper sectors have a pseudo-raphe and a single spine near the hyaline margin. Diameter .075 mm.

The species is named for Mon. E. Chenevière, of Montbéliard, France, who has discovered many rare diatoms.

Holotype, No. 3353,

ACTINOPTYCHUS GLABRATUS *incisus* Grunow
Plate 13, figure 9

Actinoptychus glabratus, var. *incisa* Grunow, 1883, in Van Heurck, Syn. Diat. Belgique pl. 120, fig. 8.—Schmidt, 1890, Atlas, Diat., pl. 154, fig. 2.

A large form agreeing closely with the plate in the "Atlas." In his synonymy of *Actinoptychus*, Mann (1907, p. 272) evidently preferred to regard *A. glabratus* as a variety of *A. splendens*. Diameter .200 mm.

Hypotype, No. 3346,

ACTINOPTYCHUS INDETERMINATUS Long, Fuge and Smith, n. sp.
Plate 13, figure 2

Valve circular with hexagonal, hyaline center; sectors six in number, separated from each other by somewhat indefinite boundaries, all closely beaded in decussating lines; beads irregular at the junction of the sectors. There is a small spine at each peripheral angle of the sectors. Diameter, .06 mm.

Holotype, No. 3347.

ACTINOPTYCHUS PACKI IMMACULATUS Long, Fuge and Smith, n. var.
Plate 13, figure 5

Valve circular, with hyaline center somewhat irregular in outline. The depressed sectors have close beading in regular decussate lines; one spine near the margin with hyaline space which forms the beginning of a pseudoraphe extending about half-way to the center. In the elevated sectors the beading is more irregular, especially towards the center; instead of spines, there are hyaline spaces corresponding in position to those in the depressed sectors. There are also triangular hyaline spaces near the margin, between each pair of sectors.

This form is equally common and somewhat larger than *A. packi* Hanna (1927, p. 12) and is distinguished from it by the entire absence of the maculate markings. When seen dry it is a much more diaphanous form. Diameter, .088 mm.

Holotype, No. 3349,

ACTINOPTYCHUS ROTULA Long,
Fuge and Smith, n. sp.
Plate 13, figures 3, 4

Valve circular with narrow hyaline margin and large polygonal hyaline center. Compartments fourteen in number. In each depressed sector there is a distinct pseudo-raphe running from the circumference to the hyaline center. The beading is regular and somewhat coarse, arranged in lines crossing at right angles; the elevated sectors have similar but slightly finer beading, no pseudo-raphe and a line of slightly larger beads close to the margin. Spines absent. Diameter, holotype .050; paratype, .0425 mm.

A specimen has been observed with hyaline border to all the sectors except at the termination of the pseudo-raphe in the depressed sectors. Here, at the end of the pseudo-raphe, there is a suggestion of a minute process or spine. This variation is worthy of note but we do not regard it as sufficiently marked to create a new variety.

Holotype, (fig. 3), No. 3350, paratype, (fig. 4), No. 3351,

ACTINOPTYCHUS SIGNATUS Long,
Fuge and Smith, n. sp.
Plate 13, figure 1

Valve circular with narrow hyaline margin and polygonal, hyaline center. All sectors, 10 in number, have close beading in lines crossing at right angles. Toward the outer part of the elevated sectors, which present a somewhat scabrous appearance, the beading is somewhat irregular. No indication of a pseudo-raphe appears in any sector. In all sectors, one fourth of the length of the radius from the circumference, there is a small hyaline space bearing one central bead or small spine, a characteristic feature of this species. There are no marginal processes of any kind. Diameter .0425 mm.

Holotype, No. 3352,

ACTINOPTYCHUS SUMMISSUS Schmidt

Actinoptychus summissus Schmidt, 1874, Atlas, Diat., pl. 1, fig. 13.

This form corresponds almost exactly with Schmidt's figure, which probably represents a recent example. In our specimen the markings seem somewhat more pronounced.

ACTINOPTYCHUS UNDULATUS
Ehrenberg, var.

Actinoptychus undulatus, Schmidt, 1874, Atlas, Diat., pl. 1, fig. 6.

A variety, characterized by an unusual central space has been noted in the Moreno samples. The specimen illustrated by Schmidt came from Monterey.

ANAULUS CALIFORNICUS Long,
Fuge and Smith, n. sp.
Plate 14, figure 2

Valve almost flat, subelliptical in shape, divided into three segments by transverse septa. Markings consist of small pearls. These are concentrically arranged about a clear center in the middle segment, and in a linear manner in the end segments. Length, .05, width, .0325 mm.

Holotype, No. 3354.

ANAULUS UNDALATUS Long,
Fuge and Smith, n. sp.
Plate 14, figure 3

Valve narrowly lanceolate with rostrate ends and undulating sides, constricted where two septa cross the diatom, finely beaded all over the surface. Length, .044, width, .0096 mm.

Holotype, No. 3355.

ARACHNOIDISCUS EHRENBERGII Bailey
Plate 13, figure 6

Arachnoidiscus ehrenbergii, Schmidt, Atlas, Diat., pl. 68, 1881, figs. 3, 4.

Specimens of this form are occasionally met with in the Moreno shale. They are somewhat small, about .1425 mm. in diameter, and differ but slightly from the type form.

Hypotype, No. 3356.

ARACHNOIDISCUS INDICUS Ehrenberg
Plate 14, figure 9

Arachnoidiscus indicus, Schmidt, 1881, Atlas, Diat., pl. 68, 1890, figs. 6 & 7, pl. 147, fig. 9.

This species, which some regard as a variety of *A. ehrenbergii* is found only very rarely. The only specimen we have seen corresponds closely to the form illustrated by Schmidt. Diameter, .059 mm.

Hypotype, No. 3357.

AULACODISCUS ALLORGEI Chenevière
Plate 13, figure 13

Aulacodiscus allorgei Chenevière, Bull. Soc. Franc. de Microscopie, vol. 3, no. 3, 1934, p. 106, pl. 8, fig. 2.

This diatom, which occurs but rarely, seems identical with the one figured by M. Chenevière from the interesting Russian deposit of Kamischev. Diameter, .147 mm.
Hypotype, No. 3358.

AULACODISCUS ALTERNANS Long, Fuge and Smith, n. sp.
Plate 14, figure 11

Valve round; surface, rising only slightly to processes, which, however, are left on broad, prominent eminences by the slant of the surface between the processes to the border, thus leaving the alternate sectors of the diatom out of focus and creating a characteristic appearance; beyond the eminences on which the processes stand the drop to the border is sudden; border definitely striated; central space clear, subcircular; markings rounded and in contact, but in places compressed to oval shape; primary rays indistinct, merging to a narrow clear space at processes; processes of medium size, bulbous with truncate apex, four in number. Diameter, .230 mm.
Holotype, No. 3359.

AULACODISCUS AMERICANUS Long, Fuge and Smith, n. sp.
Plate 13, figure 11

Valve circular; surface rising gently from a depressed, subcircular, hyaline center until about half way to processes where it forms a pronounced ridge, thence almost flat to processes, and then descends steeply to a narrow hyaline border. Close to the central space the markings are rounded, but immediately become crowded and polygonal, running in radial lines to the margin. Processes 7 or 8 in number, almost erect, inserted near the outer side of a sub-circular, hyaline space about one-fourth of the radius from the circumference; furrows closed but obvious. Diameter, .25 m.

The above description is from an imperfect specimen, the only one as yet found of this attractive form.
Holotype, No. 3360.

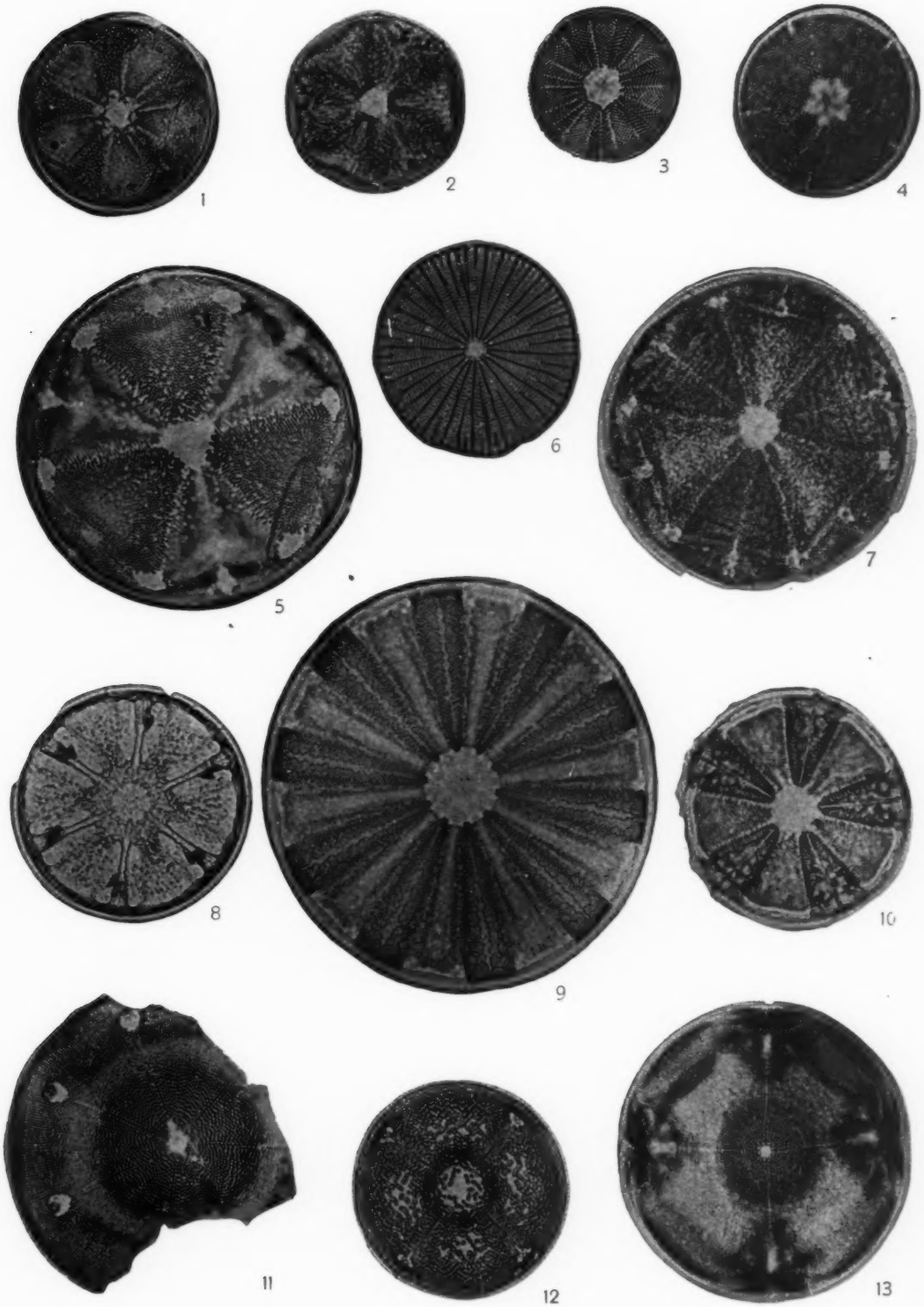
AULACODISCUS ARCHANGELSKIANUS Witt
Plate 14, figure 13

Aulacodiscus archangelskianus Witt, 1886, Verhandl., Russ. Kais. Mineral. Gesellschaft, St. Petersburg, ser. 2, vol. 22, pp. 137–177, pl. 6, fig. 11.—Schmidt, 1886, Atlas, Diat., pl. 101, figs. 7, 11.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 14, pl. 1, figs. 6, 7; (as *A. pugnalis*). —Hanna, Journ. Paleo. Vol. 8, no. 3, 1934, p. 353, pl. 48, fig. 7.

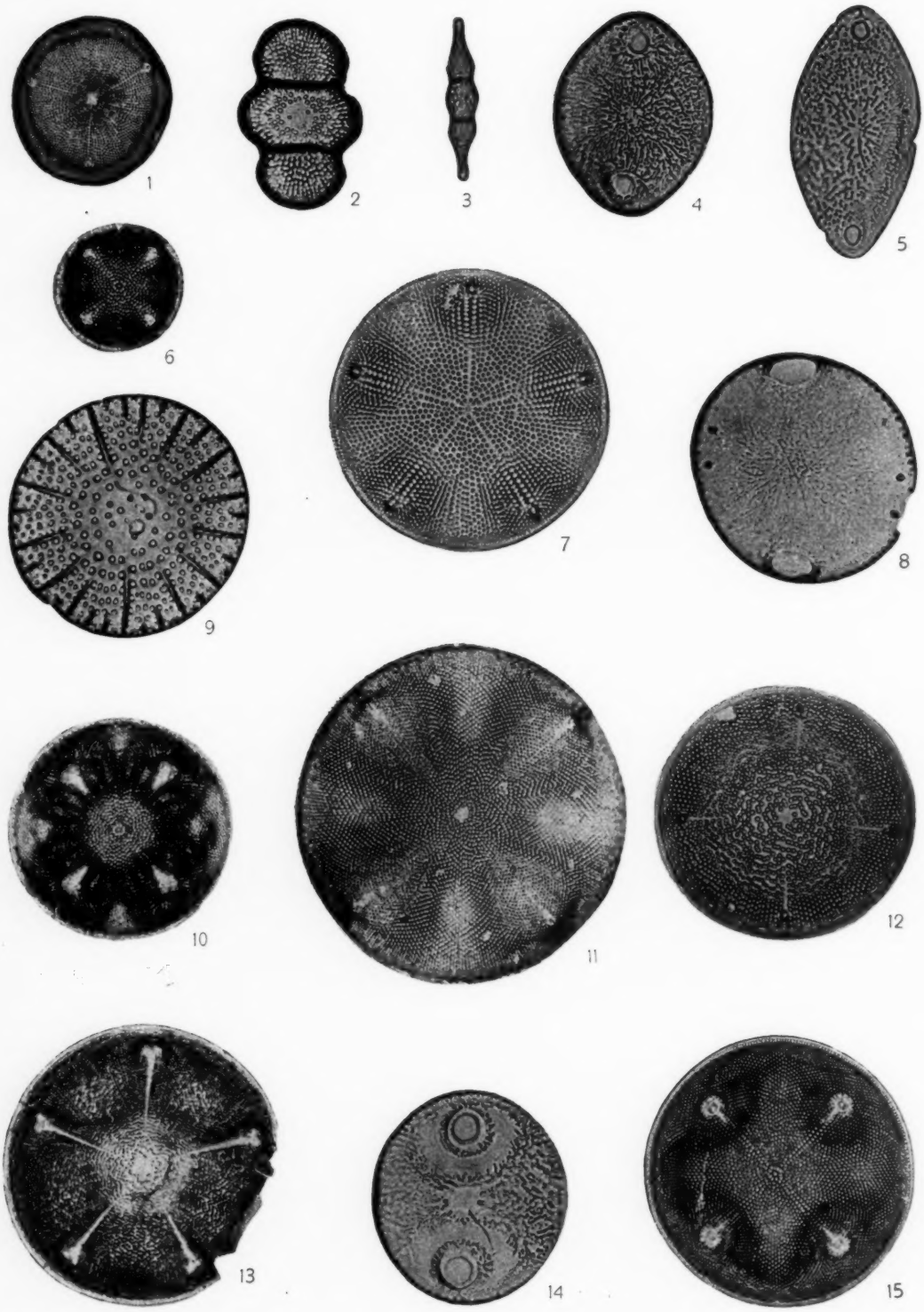
In the Moreno shale there seem to be two distinct varieties of *Aulacodiscus archangelskianus* Witt. In one, the markings fill the valve except at the center, and are definitely disposed in radiating rows, generally in contact, and at times compressed into an oval shape. The processes vary in number from three to eight. This seems identical with *archangelskianus* Witt. Diameter, .178 mm.
Hypotype, No. 3361.

EXPLANATION OF PLATE 13

FIGS. *1*—*Actinoptychus signatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .0425 mm. (p. 95)
2—*Actinoptychus indeterminatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .06 mm. (p. 94)
3, 4—*Actinoptychus rotula* Long, Fuge and Smith, n. sp., *3*, Paratype, Diam., .0425 mm.; *4*, Holotype, Diam., .050 mm. (p. 95)
5—*Actinoptychus packi* Hanna, var. *immaculatus* Long, Fuge and Smith, n. var. Holotype, Diam., .088 mm. (p. 94)
6—*Arachnoidiscus ehrenbergii* Bailey. Diam., .135 mm. (p. 95)
7—*Actinoptychus packi* Hanna. Diam., .120 mm. (p. 94)
8—*Actinodictyon weissflogii* Pautosek, var. *unca* Long, Fuge and Smith, n. var. Holotype, Diam., .059 mm. (p. 94)
9—*Actinoptychus glabratus incisus* Grunow. Diam., .200 mm. (p. 94)
10—*Actinoptychus chenevierei* Long, Fuge and Smith, n. sp. Holotype, Diam., .075 mm. (p. 94)
11—*Aulacodiscus americanus* Long, Fuge and Smith, n. sp. Holotype, Diam., .250 mm. (p. 96)
12—*Aulacodiscus archangelskianus pugnalis* Hanna. Diam., .135 mm. (p. 96)
13—*Aulacodiscus allorgei* Cheneviere. Diam., .147 mm. (p. 96)
All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms



Long, Fuge and Smith—Cretaceous Diatoms

AULACODISCUS ARCHANGELSKIANUS PUGNALIS Hanna
Plate 13, figure 12

Aulacodiscus pugnalis Hanna, Oc. Pprs. Calif. Acad. Sci. 13, 1927, p. 14, pl. 1, figs. 6, 7.—Hanna, 1934, Journ. Paleo. Vol. 8, p. 353, pl. 48, fig. 7 (as *A. archangelskianus*).

In this form the markings are not definitely radiate, but comparatively sparse, rounded and discrete. They are also larger than those of the type. The processes generally number three or four. Diameter .135 mm.

After creating the species *pugnalus* for this form Hanna later united it to *archangelskianus*. Having regard to the considerable difference in appearance, we consider it to be a distinct variety of Witt's species.

Hypotype, No. 3362.

AULACODISCUS BROWNEI Norman
Plate 14, figure 12

Aulacodiscus brownei, Schmidt, Atlas, Diat., pl. 36, 1876, figs. 15, 16, pl. 105, 1886, fig. 6.—Rattray, Journ. Roy. Mici. Soc. Vol. 8, 1888, p. 341.

It is with a little hesitation we refer two forms to this species. Each has four processes. This number, according to Rattray, is permissible for *brownei*, but the definite concentric arrangement of the markings which is so characteristic a feature in the commoner, two-processed forms, is not as definite here; consequently there is some uncertainty as to the accuracy of our diagnosis. Diameter, .080 mm.

Hypotype, No. 3363.

AULACODISCUS CELLULOSUS INFLATUS Long, Fuge and Smith, n. var.
Plate 14, figure 7

The form figured by Schmidt (1888, pl. 124, fig. 3) is very close, if not identical with this. This differs from the type from Oamaru in its contour. Here the surface is flat save along the line of processes where the rise is distinct and terminates in definite inflations. Processes four or five. An apparently identical form appears in material from Kamichev, Russia. Diameter, .135 mm.

Holotype, No. 3364.

AULACODISCUS ERECTUS Long, Fuge and Smith, n. sp.
Plate 14, figure 15

Valve circular; a flat quadrangular figure with concave margin occupies the center of the valve, its angles halfway between the processes and its concavities facing the processes. The edges of this figure rise gently but distinctly to the zone of processes and then slope more gently to the border. This contour gives a characteristic stelliform appearance to the valve. Markings consist of a central rosette whence angular cells proceed in a radiating manner to the border

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EXPLANATION OF PLATE 14

FIGS. *1*—*Aulacodiscus striatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .080 mm. (p. 98)
2—*Anaulus californicus* Long, Fuge and Smith, n. sp. Holotype, Length, .05 mm.; width, .0325 mm. (p. 95)
3—*Anaulus undulatus* Long, Fuge and Smith, n. sp. Holotype, Length, .044 mm.; width .0096 mm. (p. 95)
4—*Auliscus priscus* Long, Fuge and Smith, n. sp. Holotype, Diam., .0525×.0425 mm. (p. 99)
5—*Auliscus scutulum* Long, Fuge and Smith, n. sp. Holotype, Diqm., .065×.0325 mm. (p. 100)
6—*Aulacodiscus sagittarius* var. *distentus* Long, Fuge and Smith, n. var. Holotype, Diam., .083 mm. (p 98)
7—*Aulacodiscus cellulosus inflatus* Long, Fuge and Smith, n. var. Holotype, Diam., 135 mm. (p. 97)
8—*Auliscus hendeyi* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 99)
9—*Arachnoidiscus indicus* Ehrenberg. Hypotype, Diam., .059 mm. (p. 95)
10—*Aulacodiscus sagittarius* Long, Fuge and Smith, n. sp. Holotype, Diam., .142 mm. (p. 98)
11—*Aulacodiscus alternans* Long, Fuge and Smith, n. sp. Holotype, Diam., .230 mm. (p. 96)
12—*Aulacodiscus brownei* Norman. Diam., .080 mm. (p. 97)
13—*Aulacodiscus archangelskianus* Witt. Diam., .178 mm. (p. 96)
14—*Auliscus bubo* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 99)
15—*Aulacodiscus erectus* Long, Fuge and Smith, n. sp. Holotype, Diam., .160 mm. (p. 97)

All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Panoche Hills, Fresno County, California.

Near the margin these cells become slightly smaller and then terminate in a row of oblong cells surrounded by a clear border. Primary rays well marked, becoming open near the processes. Processes four in number, of moderate size, placed about one fourth of the radius within the valve and set in an unusual manner, almost erect, but pointing slightly toward the center of the valve. Diameter, .160 mm.

Holotype, No. 3365.

AULACODISCUS LAHUSENII MARGINALIS Witt

Aulacodiscus lahusenii marginalis Witt, 1886, Verhandl. Russ. Kais, Mineral. Gesellschaft St. Petersburg, ser. 2, vol. 22, pp. 137–177, pl. 7, fig. 3—Schmidt, 1886, Atlas, Diat., pl. 101, fig. 4.

The specimen that has been found corresponds closely to the illustrations cited above except that it has more of the irregular pearls in the center.

AULACODISCUS MORENOENSIS Long, Fuge and Smith, n. sp.
Plate 18, figure 3

Valve round; surface sunken at center, rising to the zone of processes to form a distinct narrow ridge, pentagonal in shape (when the processes are five), beyond this dropping to a flat margin. Within the processes the markings consist of discrete rounded puncta, irregularly arranged within but becoming radiate as they approach the zone of processes; beyond the raised area the markings are smaller and arranged in radiating striae. Primary rays distinct at the outer third; clear space at process evident but small. Processes long, narrow, cylindrical, from three to eight in number. Diameter, .080 mm.

This diatom is not uncommon, but the valve is evidently delicate for it is usually much corroded. The description and illustration are taken from one of the rare, uncorroded specimens.

Holotype, No. 3366.

AULACODISCUS RELLAE Hanna and Grant

Aulacodiscus rellae Hanna and Grant, Proc. Calif. Acad. Sci., ser. 4, vol. 15, 1926, pl. 13, figs. 5, 6.

This diatom has considerable points of resemblance to *A. barbadensis* Ralfs and *A. notatus* Grove and Sturt. The suggestion has been made that both should be united under *A. barbadensis*, but we concur in regarding them as definitely distinct.

AULACODISCUS SAGITTARIUS Long, Fuge and Smith, n. sp.
Plate 14, figure 10

Valve round; in contour, flat at center, rising boldly to the zone of processes. Between the processes the area is more or less concave and the raised portion drops sharply to a broad flat border. At the center, markings form a large rosette with clear central space. The markings themselves consist of rounded cellules in contact with each other, larger on the furrows, smaller below the raised area; margin with well-marked striae. The processes are of medium size, three or four in number with the proximal portion the smaller. Primary rays well marked, broadening to a "V" shaped clear space at the base. Diameter, .142 mm.

Holotype, No. 3367.

AULACODISCUS SAGITTARIUS DISTENTUS Long, Fuge and Smith, n. var.
Plate 14, figure 6

In var. *distentus* the raised area is barely concave between the processes, and gives the impression of a cushion-shaped structure placed upon a flat valve. Diameter, .083 mm.

The diatom will find a place in Rattray's group "*inflati*."

Holotype, No. 3368.

AULACODISCUS STRIATUS Long, Fuge and Smith, n. sp.
Plate 14, figure 1

Center slightly depressed, rising gently to the zone of processes whence it drops in a sharp curve to the margin; no compartments between the processes; center clear, angular; markings compressed, oval out to the zone of processes where they become smaller and round and form conspicuous radiate striae to the margin. Primary rays distinct, their markings in contact until they widen to a broad V-shaped space at the processes. Processes three in number, cylindrical. Diameter, .080 mm.

Holotype, No. 3369.

AULISCUS BUBO Long,
Fuge and Smith, n. sp.
Plate 14, figure 14

The surface slopes gently from the central space to the margin. There is a hyaline center almost square in shape, the ocelli, two in number, are round and of medium size, around each ocellus there is a narrow crescent of irregular puncta and within this, towards the center a much larger hyaline crescent. The rest of the surface is set with irregular striae which appear to consist of confluent puncta.

The valve is subcircular, measuring .0525 mm. by .05 mm.

Holotype, No. 3370.

AULISCUS DILECTUS Long, Fuge and
Smith, n. sp.
Plate 15, figure 14

Valve, circular; surface slightly convex save where it rises gently to the ocelli. The markings consist of delicate, curved striae passing from the central area to the border and the ocelli; in places, chiefly near the ocelli, these may be resolved into dots with a high power. Between the ocelli and the center there is a rectangular, subhyaline marking which appears to be caused by the suppression of some of the striae rather than by any great difference in the valve contour. Ocelli two, subcircular. Between the ocelli, near the border but not symmetrically placed are two large rounded markings about one fifth of the diameter of the ocelli; each consists of a hyaline lacuna in the valve surface in the center of which stands a pearl. Diameter, .04 mm. to .10 mm.; holotype, .095 mm.

This diatom is closely related to *Auliscus vallatus*.

Holotype, No. 3371.

AULISCUS HARDMANIANUS MACULOSUS
Long, Fuge and Smith, n. var.
Plate 15, figure 4

This diatom, which resembles in general appearance that illustrated by Greville (1865, pl. 11, fig. 17) and Schmidt (1881, pl. 67, fig. 1; 1886, pl. 89, fig. 4) differs from the type in the considerable prominence of the obconical areas and also in the fact that all the striae consist of lines of fine, clear dots. These are easily made out with a high magnification. Diameter, .059 mm.

Holotype, No. 3372.

AULISCUS HENDEYI Long, Fuge and
Smith, n. sp.
Plate 14, figure 8

Valve subcircular, three-fourths of the surface flat with a gentle slope to the border. The markings proceed from an ill-defined central point and consist of fine striations which are roughly radiate in disposition and which do not resolve into puncta. A row of coarse apiculi surrounds the margin except where broken by the ocelli; also on each side near the margin and roughly midway between the ocelli are two small but perfectly distinct puncta or apiculi. The ocelli are two in number, elliptical and hyaline and set at the extreme margin. Diameter, .05 mm.

Holotype, No. 3379.

The species is named for N. Ingram Hendey, F.R.M.S., of the British Museum (Natural History) who has generously given much help in the preparation of this paper.

AULISCUS PALEACEUS Long, Fuge and
Smith, n. sp.
Plate 15, figure 2

Valve, circular; the central portion is flat with slight rise to the ocelli, dropping gently at about the outer third to the border. There is a small hyaline center. The markings consist of striations of fine dots irregularly placed, of which many, especially in the central area, anastomose and give a granular appearance to the valve. Ocelli two in number, subcircular and hyaline. Diameter, .0425 mm.

Holotype, No. 3373.

AULISCUS PRISCUS Long, Fuge and
Smith, n. sp.
Plate 14, figure 4

Valve broadly elliptical, surface almost flat with ocelli slightly raised; center hyaline with a few scattered puncta; surface irregularly striated with signs of convergence to the ocelli which are two in number, round, hyaline and surrounded with a few irregular apiculi. Diameters, .0525 mm. and .0425 mm.

Holotype, No. 3374.

AULISCUS SCUTULUM Long, Fuge and Smith, n. sp.
Plate 14, figure 5

Valve narrowly elliptical; surface rising in a gentle curve from the margin to a small, circular, hyaline center. There is a row of fine dots around the margin; the other markings consist of broken rows of rather coarse puncta, very sparsely distributed, which run from the center to the margin; other similar dots are interspersed as they approach the border. The subcircular ocelli are two in number, symmetrically placed near the ends and each is surrounded by a ring of fine puncta. Length, .065; width, .0325 mm.

Holotype, No. 3375.

AULISCUS SPISSUS Long, Fuge and Smith, n. sp.
Plate 15, figure 1

Valve circular; two round finely dotted ocelli, each with one central punctum. The surface is densely but finely striated, radially near the margin, and more irregularly towards the center. Surface apiculate except for two lunate spaces near the margin, between the ocelli. Diameter, .046 mm.

Holotype, No. 3376.

AULISCUS TRIOCULATUS Long, Fuge and Smith, n. sp.
Plate 15, figure 7

Valve circular; the central area flat and sloping gently towards the margin. There is a small hyaline center bearing a few scattered puncta whence puncta crowd into irregular lines radiate towards the margin, curving towards the ocelli. Towards the margin the lines of puncta become finer. Ocelli three in number, circular, hyaline, set a short distance within the border. Diameter, .0675 mm.

Holotype, No. 3377.

AULISCUS WHARTONI Long, Fuge and Smith, n. sp.
Plate 15, figure 13

Valve circular; surface almost flat but rising to the processes. The markings consist of close lines of fine beads which proceed from the indistinct center, where the beads are more irregular. These lines run radially or subradially to the margin, and also in a curved manner to the processes. Ocelli two in number, themselves closely beaded and almost suborbicularly triangular in shape. Diameter, .085 mm.

Holotype, No. 3378.

This form is named for Dr. Charles G. Wharton of Los Angeles, who gave valued assistance in collecting the material upon which this paper is based.

BIDDULPHIA APICULATA Long, Fuge and Smith, n. sp.
Plate 15, figure 3

Valve subcircular, in general appearance resembling *Lampriscus*. At the margin three ocelli alternate with three large apiculi. Markings consist of close, fine striae roughly radiate over the surface, but curving somewhat around the ocelli. Over this is a thin reticulum with numerous apiculi. Diameter, .025 mm.

Holotype, No. 3380.

BIDDULPHIA GUROWII Pantocsek

Biddulphia gurowii Pantocsek, 1893, Beit. Kennt. Foss. Bac. Ungarns, pt. 3, pl. 24, fig. 366.

A form which seems in every way identical with this has been observed in the Moreno shale. It should be noted that Pantocsek's species was found in the Russian deposits at Kusnetzk.

BISSULPHIA IMPRESSA Long, Fuge and Smith, n. sp.
Plate 15, figure 8

Valve rounded in outline; from a flat border there rises an oval mound upon which the two typical cerataulloid processes are placed. The markings consist of fine striae which can be resolved into dots under high magnification. These striae radiate from the center and cover the whole valve including the processes. There are no spines or apiculi, but a number of dark spots are disposed irregularly upon the raised portion. Diameter, .070 mm.

This diatom evidently finds its place in the group known as *Cerataulus*.

Holotype, No. 3381.

BIDDULPHIA LACUNOSA Long, Fuge and Smith, n. sp.
Plate 15, figure 10

Valve elliptico-rostrate in shape, almost flat, terminated by biddulphoid processes; surface covered with faint striations which are interrupted by four lunate hyaline spaces; the inner pair leave an almost circular striated portion at the center of the valve, and the outer pair lie close to the processes. The central portion bears one or more spines. Length, .040, width, .0175 mm.

Holotype, No. 3445.

The specimen from which the photograph and description were made was accidentally lost. Another has been selected as holotype which differs in no essential respects from the original except that it is slightly larger. Length, .0452 mm.

BIDDULPHIA LONGAEVA Long, Fuge and Smith, n. sp.
Plate 15, figure 11

Valve elliptical with pointed ends; surface almost flat, divided into three parts by narrow channels. The large middle part has a hyaline center with lines of sparse pearls distributed in a roughly radial manner, the pearls being especially scarce near the center. The terminal portions of the valve have closer lines of pearls growing smaller in size as they approach the biddulphoid processes at the ends of the valve. Length, .1125, width, .0675 mm.

Holotype, No. 3382.

BIDDULPHIA ? PERPLEXA Long, Fuge and Smith, n. sp.
Plate 15, figure 5

Valve widely elliptical with rounded ends; surface almost flat, divided into three parts by two straight channels. The central part is finely striated in indefinite radial lines. Each channel has close puncta on each side. The end portions of the valve are also finely striated but not radially. The processes were missing but judging by the fracture, they were large. Length, .060, width, .0425 mm.

This form can only be placed provisionally in *Biddulphia* since the only specimen observed was imperfect and no trace of the processes remained. One of the "channels" was curtailed about two thirds across the valve. This was possibly an individual rather than a specific character.

Holotype, No. 3383.

BIDDULPHIA PRIMORDINALIS Long, Fuge and Smith, n. sp.
Plate 17, figure 19

Valve oblong with four definite protrusions on each of which is situated a slightly raised process, divided by costae into three parts. Processes finely dotted, the rest of the valve bearing irregularly scattered, coarser puncta. Length .1254, width at central processes, .070 mm.

Holotype, No. 3384.

BIDDULPHIA SUBORBICULATA Long, Fuge and Smith, n. sp.
Plate 15, figure 6

Valve suborbicular, obscurely three-sided; flat from the center to a distance of about half the diameter where there is a broad ridge on whose outer edge stand three cerataulloid processes which reach the border; between the processes the border is flat and on the same plane as the center of the valve. At the center of the valve stands a punctum surrounded by a small granular, oval space from whence delicate striae radiate to the processes and the border. The center and the ridge bear many irregularly disposed, coarse apiculi. On the ridge between each pair of processes are four long, stout spines. The flat portion of the border is clear but the margin itself is fringed with densely crowded apiculi. Diameter, .09 mm.

There is an obvious resemblance between this form and *Cerataulus subangulatus* Grove and Sturt, of Oamaru, and if, as seems necessary, a new genus is created for that form this should accompany it.

Holotype, No. 3385.

BIDDULPHIA TUOMEYII Bailey

Biddulphia tuomeyii, Schmidt, 1888, Atlas, Diat., pl. 119, figs. 1, 8, 15, 17.

This widely spread diatom is not frequent in the Moreno shale. The forms are generally small and correspond most closely, perhaps, to those figured by Schmidt.

BIDDULPHIA UNDULATA Long, Fuge and Smith, n. sp.
Plate 15, figure 9

Valve narrowly elliptical; surface divided into three unequal parts by narrow channels. The central portion, which is elevated and almost square, has a small hyaline center whence proceed radial lines of small pearls, set fairly close. The terminal portions have similar pearls in long lines directed towards the center. Across the middle of each terminal portion is a depressed zone where the lines of pearls are somewhat interrupted. At each end is a raised process whose upper part is subtriangular and marked by about six rows of dots arranged longitudinally. Length, .120, width, .04 mm.

Holotype, No. 3386.

CENTROPORUS CALIFORNICUS Long, Fuge and Smith, n. sp.
Plate 16, figure 8

Valve circular, with a striking border one-sixth of the diameter in breadth. The inner portion is yellowish and granular, the color and markings suggesting those of *Hyalodiscus*. The central area, about one-third of the diameter, consists of a thirteen pointed star. The rest of the area within the border is divided by narrow lines into thirteen tongue-shaped segments. On the border, between each of the thirteen lines is a hyaline oblong compartment of about half the breadth of the border. The radial lines of these and also the lines forming the compartments are continued across the border. Except on the star-shaped portion and on the hyaline parts of the border the whole diatom is covered by very fine, punctate striae. Diameter, .070 mm.

We have not seen Pantocsek's type specimen of *Centroporus crassus* (1889, pl. 4, fig. 57), but judging from the figure there is good reason for placing this in the same genus.

Because it presents different aspects at different foci, this valve is not easy to describe or to photograph.

Holotype, No. 3387.

CLADOGRAMMA MORENOENSIS Long, Fuge and Smith, n. sp.
Text figure 2

Valve circular, the surface rising conically from a wide, upright, hyaline girdle. The surface is hyaline with striations consisting of broken lines of various sizes and shapes which run subradially to the center. Diameter, .050 mm.

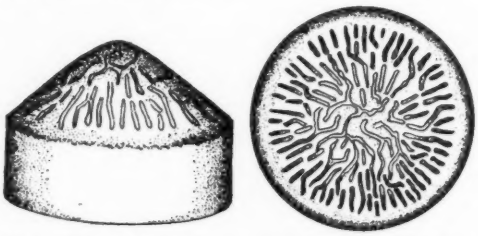


FIG. 2.—*Cladogramma morenoensis* Long, Fuge and Smith, n. sp. Holotype. Diam., 050 mm.

In general appearance this diatom resembles *C. conicum* figured by Greville, (1865b, pl. 8, figs. 1, 2) but in that species the markings are distinctly continuous and radiate and the girdle is as distinctly marked as the surface.

Holotype, No. 3444.

COSCINODISCUS CIRCUMSPECTUS Long, Fuge and Smith, n. sp.
Plate 15, figure 12

Valve flat, a small irregular rosette standing at the center. The markings are hexagonal, subequal to the border, six in .01 mm., disposed in radial rows. The border is limited on the inner side by a row of slightly larger markings which are almost oblong and which seem to be continued as apiculi overlying the narrow clear border. Diameter, about .090 mm.

Holotype, No. 3388.

COSCINODISCUS CLARESCENS Long, Fuge and Smith, n. sp.
Plate 16, figure 6

Valve flat, the central space small and clear, sometimes surrounded by an indistinct rosette. The markings, arranged in a radiate manner, are irregularly compressed into various shapes; some are almost square, subequal, five in .01 mm.; near the border two or three rows become much smaller showing as rounded pearls with clear interspaces. The border possesses well-defined striae. Diameter, about .07 mm.

Holotype, No. 3389.

COSCINODISCUS CONVEXUS Schmidt

Coscinodiscus conuexus Schmidt, 1877, Atlas, Diat., pl. 60, fig. 15.—Hanna, 1932, Calif. Acad. Sci., Proc., ser. 4, vol. 20, p. 179, pl. 6, fig. 2, 3, pl. 7, fig. 1.

This interesting diatom with its well marked secondaries is by no means rare. The figure given in Schmidt's Atlas is not very satisfactory.

COSCINODISCUS DEFINITUS Long, Fuge and Smith, n. sp.
Plate 16, figure 1

Valve circular; surface flat for about two thirds of the diameter then it falls gently to the narrow, finely marked margin. The markings consist of coarse pearls varying little in size, but becoming slightly smaller near the margin. At the margin these are arranged in a sub-concentric manner, but as the center is approached the arrangement is lost and hyaline interspaces appear, largest towards the center. Towards the outer half the beads can be observed in curved, decussating lines. Diameter, .060 mm.

Holotype, No. 3390.

COSCINODISCUS DENARIUS Schmidt

Coscinodiscus denarius Schmidt, Atlas, Diat., pl. 57, 1877, fig. 20.

A few forms which seem to correspond to the figure cited have been found in the Moreno samples.

COSCINODISCUS DISTINCTUS Long, Fuge and Smith, n. sp.
Plate 15, figure 15

Valve circular and slightly convex. Markings consist of large polygonal alveoli arranged in transverse lines somewhat after the manner of *Coscinodiscus excentricus* and largest toward the center; each alveolus presents a secondary structure consisting of an eye-spot surrounded by a ring of fine dots. The bold margin is finely striated on the outer side, while on the inner, it is provided with two or three rows of puncta. Diameter, .170 mm.

The one valve examined possessed a minute and easily overlooked central space which may possibly not be found in other specimens.

Holotype, No. 3391.

COSCINODISCUS DUPLEX Long, Fuge and Smith, n. sp.
Plate 16, figure 7

Valve circular, the narrow margin divided into small squares; surface slightly curved; radial rows of pearls gradually diminishing in size run half way to the center. The central area is raised and almost flat, with radial rows of cellules, which are a continuation of the outer rows. These run to a small circular hyaline center in which is a prominent nodule. Diameter, .05 mm.

This is a very distinctive species.

Holotype, No. 3392.

COSCINODISCUS INORDINATUS Long, Fuge and Smith, n. sp.
Plate 18, figure 6

Margin, narrow, bearing one or two puncta which are carried over from the edge of the valve and form radial rows of minute puncta; valve surface almost flat with clear puncta scattered over the whole except for a small circular hyaline center. Diameter, .06 mm.

Holotype, No. 3393.

COSCINODISCUS LINEATUS Ehrenberg
Plate 16, figure 5

Coscinodiscus lineatus, Schmidt, 1877, Atlas, Diat., pl. 59, figs. 27, 29.—Hanna, 1932, Calif. Acad. Sci. Proc., ser. 4, vol. 20, p. 180, pl. 8, figs. 1–3.

The forms we have noticed correspond to the diatom referred to by Hanna. They have hexagonal markings, considerably larger in proportion, when compared with the forms more usually met with and illustrated in the Atlas.

Hypotype, No. 3394.

COSCINODISCUS MACULOSUS Long, Fuge and Smith, n. sp.
Plate 15, figure 16

Valve flat for three-fourths of radius whence it slopes gently to the border. A central space, irregularly rounded, contains a few scattered pearls. The markings consist of radial rows of rounded pearls about 9 in .01 mm., extending from the central space to the narrow border. The valve face displays a number of irregular clear spaces chiefly on the inner half. Diameter, .08 mm.

Holotype, No. 3395.

COSCINODISCUS MARGINATUS Ehrenberg
Plate 16, figure 13

Coscinodiscus marginatus, Rattray, 1889, Roy. Soc. Edinburgh Proc., vol. 16, p. 509.—Schmidt, 1877, Atlas, Diat., pl. 62, figs. 1, 2, 3, 4, 5, 9, 11 & 12, (teste Rattray).—Mann, 1907, U. S. Nat. Herb. Cont., vol. 10, pt. 5, p. 253, pl. 49, fig. 2.

Great confusion exists in the group of *Coscinodiscus* to which this form belongs. *C. marginatus* Ehrenberg is not only extremely variable but shades gradually into species bearing other distinctive names. Between *C. robustus* Greville and *C. marginatus* Ehrenberg the confusion is intolerable and possibly will only be dispelled by merging the two species.

The form under consideration here is very close to that illustrated by Mann which he named "*marginatus*," and equally close to the form in Schmidt's Atlas, pl. 62, fig. 5 which is termed by Schmidt "*robustus*," but which Rattray corrected to *marginatus*. This diatom is not common in the Moreno shale, but abounds in other, later, Californian deposits.

Hypotype, No. 3396.

COSCINODISCUS MORENOENSIS Hanna
Plate 17, figure 3

Coscinodiscus morenoesis Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 18, pl. 2, figs. 3, 4.

This form is dominant in the Moreno shale and is worthy of close study. The center with a slightly eccentric clear space and what appears to be a nodule is characteristic. The diagrammatic section of the valve suggests that what appears to be a nodule may bea siliceous rod or tube uniting the frustules as in *Thalassiosira*. Most of the valves are in fragments, and the fact that the centers are generally damaged somewhat confirms this theory.

We illustrate (plate 17, figure 3) a most interesting variant of this diatom. It possesses the typical nodule and clear space at the center, but at about a third of the radius from the center there is a distinct ridge as in *Craspedodiscus*. The striation within the ridge is discontinuous with that without, and the inner portion of the diatom is distinctly sunken. We do not presume to suggest what is the relationship of this form to *Craspedodiscus*. Diameter, .125 mm.

Hypotype, No. 3397.

COSCINODISCUS NITIDULUS Grunow
Plate 16, figure 12

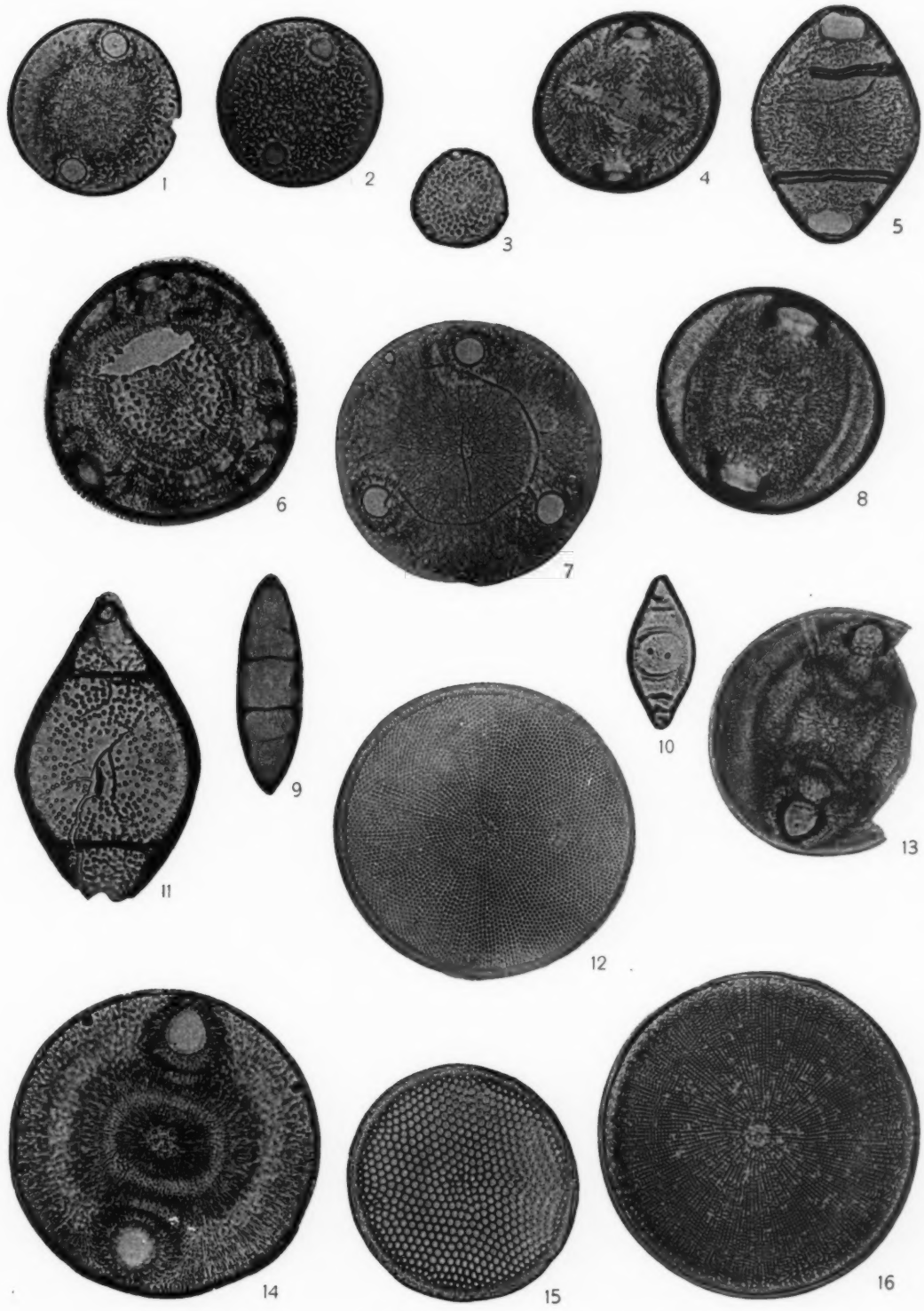
Coscinodiscus nitidulus, Schmidt, 1877, Atlas, Diat., pl. 58, fig. 20.—Hanna and Grant, 1926, Calif. Acad. Sci. Proc., ser. 4, vol. 15, p. 141, pl. 15, fig. 10.

This diatom, which betrays little evidence of fasciculation, is closer to the figure given by Hanna and Grant than that of the Atlas. Diameter, .040 mm.

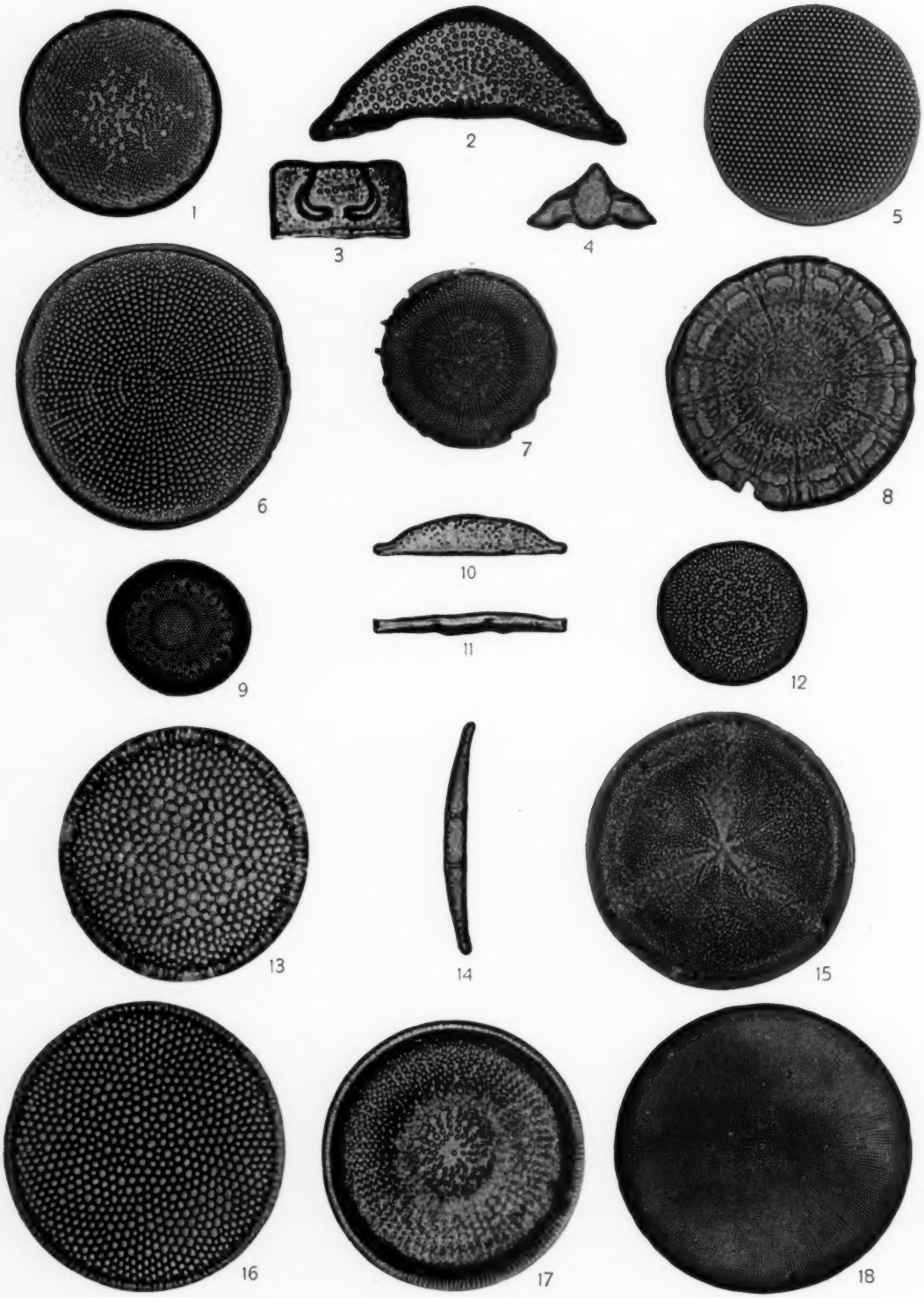
Hypotype, No. 3398.

EXPLANATION OF PLATE 15

FIGS. *1*—*Auliscus spissus* Long, Fuge and Smith, n. sp. Holotype, Diam., .046 mm. (p. 100)
2—*Auliscus paleaceus* Long, Fuge and Smith, n. sp. Holotype, Diam., .0425 mm. (p. 99)
3—*Biddulphia apiculata* Long, Fuge and Smith, n. sp. Holotype, Diam., .025 mm. (p. 100)
4—*Auliscus hardmanianus maculosus* Long, Fuge and Smith, n. var. Holotype, Diam., .059 mm. (p. 99)
5—*Biddulphia (?) perplexa* Long, Fuge and Smith, n. sp. Holotype, Length, .060, width, .0425 mm. (p. 101)
6—*Biddulphia suborbiculata* Long, Fuge and Smith, n. sp. Holotype, Diam., .09 mm. (p. 101)
7—*Auliscus trioculatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .0675 mm. (p. 100)
8—*Biddulphia impressa* Long, Fuge and Smith, n. sp. Holotype, Diam., .070 mm. (p. 100)
9—*Biddulphia undulata* Long, Fuge and Smith, n. sp. Holotype, Length, .12, width, .04 mm. (p. 102)
10—*Biddulphia lacunosa* Long, Fuge and Smith, n. sp. Length, .04, width, .0175 mm. (p. 101)
11—*Biddulphia longaeva* Long, Fuge and Smith, n. sp. Holotype, Length, .1125, width, .0675 mm. (p. 101)
12—*Coscinodiscus circumspectus* Long, Fuge and Smith, n. sp. Holotype, Diam., .09 mm. (p. 102)
13—*Auliscus whartoni* Long, Fuge and Smith, n. sp. Holotype, Diam., .085 mm. (p. 100)
14—*Auliscus dilectus* Long, Fuge and Smith, n. sp. Holotype, Diam., .095 mm. (p. 99)
15—*Coscinodiscus distinctus* Long, Fuge and Smith, n. sp. Holotype, Diam., .17 mm. (p. 103)
16—*Coscinodiscus maculosus* Long, Fuge and Smith. n. sp. Holotype, Diam., .08 mm. (p. 103)
All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms



Long, Fuge and Smith—Cretaceous Diatoms

COSCINODISCUS OBSCURUS Schmidt
Plate 16, figure 16

Coscinodiscus obscurus Schmidt, 1877, Atlas, Diat., pl. 61, fig. 16.—Rattray, 1889, Roy. Soc. Edinburgh Proc., vol. 16, p. 513.

Forms agreeing closely with the above are found from time to time, in the Moreno samples though they are by no means frequent. Diameter, .088 mm.

Hypotype, No. 3399.

COSCINODISCUS STEINYI Hanna

Coscinodiscus steinyi Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 19, pl. 2, figs. 5, 6.

This diatom occurs in great abundance, second only to *C. morenoensis*.

COSCINODISCUS SUBTILIS Ehrenberg, var.
Plate 16, figure 18

Coscinodiscus subtilis Schmidt, 1877, Atlas, Diat., pl. 57, figs. 11, 13, 28, 29; 1877, pl. 58, fig. 37.—Van Heurck, Syn. Diat. Belgique, pl. 131, 1883, fig. 1.—Van Heurck, Treat. Diat., 1896, pl. 34, fig. 901.—Rattray, Proc. Roy. Soc. Edinburgh, Vol. 16, 1889, p. 494.

The representative of this varying and widely distributed form differs from the generally accepted type in its somewhat larger size, less obvious "fasciculi" and somewhat strongly striated border. Diameter, .145 mm.

Hypotype, No. 3400.

COSCINODISCUS SUPERBUS CALIFORNICUS
Long, Fuge and Smith, n. var.
Plate 16, figure 17

Cestodiscus pulchellus Greville, 1866, Micr. Soc. London Trans., vol. 14, p. 123, pl. 11, fig. 5.—Rattray, 1889, Roy. Soc. Edinburgh Proc., vol. 16, p. 458.

The forms observed differ from the type in that the brilliant markings are more crowded and the prominent apiculi mentioned by Rattray are not to be seen. Diameter, .085 mm. We regard the difference sufficient to constitute a new variety.

Holotype, No. 3401.

CRASPEDODISCUS MORENOENSIS Long,
Fuge and Smith, n. sp.
Plate 17, figure 1

This diatom is a replica of the smaller types of *Coscinodiscus morenoensis* Hanna which is so common in the shale, but possesses a slightly eccentric, sub-oval or pear-shaped depression, distinctly delimited and depressed in the typical Craspedodiscoid manner. It can hardly be regarded as a freak as a number of similar forms have been detected. It raises many problems, chiefly the soundness of *Craspedodiscus* as a genus, and its relation to *Coscinodiscus* which cannot be dealt with here. After considerable

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EXPLANATION OF PLATE 16

FIGS. *1*—*Coscinodiscus definitus* Long, Fuge and Smith, n. sp. Holotype, Diam., .06 mm. (p. 103)
2—*Triceratium lunatum* Long, Fuge and Smith, n. sp. Holotype, Length, .080 mm. (p. 114)
3—*Terpsinoe anguinea* Long, Fuge and Smith, n. sp. Holotype, Length, .046; width, .035 mm. (p. 112)
4—*Eunotogramma sp.* Length, .065 mm. (p. 106)
5—*Coscinodiscus lineatus* Ehrenberg. Diam., .068 mm. (p. 103)
6—*Coscinodiscus clarescens* Long, Fuge and Smith, n. sp. Holotype, Diam., .07 mm. (p. 102)
7—*Coscinodiscus duplex* Long, Fuge and Smith, n. sp. Holotype, Diam., .05 mm. (p. 103)
8—*Centroporus californicus* Long, Fuge and Smith, n. sp. Holotype, Diam., .07 mm. (p. 102)
9—*Stephenopyxis rudis* Greville. Diam., .090 mm. (p. 111)
10, 11—*Eunotogramma productum* Grunow, var. *rectum* Long, Fuge and Smith, n. var.; *10*, Holotype, Length, .050, width, .009 mm.; *11*, Paratype (p. 106)
12—*Coscinodiscus nitidulus* Grunow. Diam., .040 mm. (p. 104)
13—*Coscinodiscus marginatus* Ehrenberg. Diam., .125 mm. (p. 104)
14—*Eunotogramma margino punctatum* Long, Fuge and Smith, n. sp. Holotype, Length, .06, width, .0056 mm. (p. 106)
15—*Debya californica* Long, Fuge and Smith, n. sp. Holotype, Diam., .133 mm. (p. 106)
16—*Coscinodiscus obscurus* Schmidt. Diam., .088 mm. (p. 105)
17—*Coscinodiscus superbus* Hardman, var. *californicus* Long, Fuge and Smith, n. var. Holotype, Diam., .085 mm. (p. 105)
18—*Coscinodiscus subtilis* Ehrenberg var. Diam., .145 mm. (p. 105)
All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.

consideration we have decided to create the new species, and would call attention to the form as worthy of careful study. Diameter, .072 mm.

Holotype, No. 3402.

DEBYA CALIFORNICA Long, Fuge and Smith, n. sp.
Plate 16, figure 15

The presence of this diatom is of considerable interest for it sheds light on a controverted genus. Pantocsek created the genus for a form found by him in a Hungarian deposit and which he named *D. insignis* (1886, p. 65; Van Heurck, 1896, p. 495; Karsten, 1928, p. 219; Schmidt, 1875, pl. 29, fig. 11; Coupin, 1930, pl. 293, fig. D). Ralfs, Van Heurck and Hustedt have regarded it as a "plate" or "internal valve" of *Actinoptychus*. Karsten on the other hand is inclined to admit its validity.

In the Moreno shale several of these valves have been found, mostly imperfect, but one, the specimen from which the figure has been prepared, is complete. This is an attractive form and gives every suggestion of a complete diatom valve. Comparison with figures of Pantocsek's form, reveals a close relationship therewith, but at the same time a number of differences compel us to create a new species which we define as follows:

Valve circular, .050 to .133 mm. in diameter. At the highest focus there are three narrow ridges proceeding from the center to just within the border and terminating in small processes which are somewhat aulacodiscoid in character. Between the ridges are depressions, deepest on the inner side which rise gradually towards the border until they reach almost to the plane of the processes. There is no distinction of marking at the border. The markings consist of fine puncta irregularly arranged which extend all over the valve. Over the puncta is spread a fine but well-marked reticulum. At the center there is a single punctum from which the ridges proceed, while alternating with the ridges, but proceeding only a short way into the compartments are three hyaline lines. The valve thus possesses features which suggest relationship both with *Aulacodiscus* and *Actinoptychus*. Diameter, .133 mm.

Holotype, No. 3403.

ENDYCTIA OCEANICA Ehrenberg

Endyctia oceanica, Schmidt, 1881, Atlas, Diat., pl. 65, fig. 10.—Rattray, 1889, Proc. Roy. Soc. Edinburgh, p. 469, vol. 16.

This diatom is familiarly known under the above name and as *Coscinodiscus concavus* Gregory. We prefer the earlier, as the distinctively marked border seems to mark *Endyctia* off from *Coszindiscus* and any scheme that will reduce the vast horde of species in this great genus is welcome.

EUNOTOGRAMMA sp.
Plate 16, figure 4

This resembles *E. weissii* in shape but is divided into three segments by deep depressions of the valve. The central segment is pear-shaped; the terminal segments end in an acute angle. The markings consist of irregularly scattered, coarse puncta save on the terminal segments where the puncta are finer and arranged in lines. Length, .065 mm. Unfortunately, the only specimen found was accidently lost after the description and photograph were made. It is apparently an undescribed form but a name has not been assigned to it, pending the finding of additional material.

EUNOTOGRAMMA MARGINOPUNCTATUM Long, Fuge and Smith, n. sp.
Plate 16, figure 14

Long and narrow like a shallow crescent. A septum on each side of the middle crosses the diatom. Along each margin there is a row of fine beads irregularly distributed. Length, .060, width .0056 mm.

Holotype, No. 3404.

EUNOTOGRAMMA PRODUCTUM RECTUM Long, Fuge and Smith, n. var.
Plate 16, figures 10, 11

This little diatom seems to correspond closely to Grunow's form (Van Heurck, 1883, pl. 126, fig. 5; Schmidt, 1889, pl. 144, figs. 12, 14) from Russia save that the variety has a straight ventral line and is not constricted at the segments. Length, .050, width, .009 mm.

Holotype, No. 3406.

EUPODISCUS RADIATUS Bailey
Plate 17, figure 2

Eupodiscus radiatus Greville, 1860, Micr. Soc. Quart. Journ., vol. 8, pl. 5, fig. 10.—Van Heurck, 1883, Syn. Diat. Belgique, pl. 118, figs. 1, 2.—Rattray, 1888, Roy. Micr. Soc. Journ., vol. 8, p. 913.

The form we illustrate seems identical with that referred to above save that the well marked margin of the type is absent and the cellules do not diminish in size noticeably at the border. Diameter, .112 mm.

Hypotype, No. 3407.

GLORIOPTYCHUS CALLIDUS Hanna

Glorioptychus callidus Hanna, 1927, Calif. Acad. Sci., Oc. Pprs. 13, pl. 2, figs. 7, 8.

This most interesting diatom occurs frequently in the Moreno shale.

HENDEYA Long, Fuge and Smith, n. gen.

Valve elliptical with irregularly radial, close-set striae with an ocellus and a blunt spine toward each end.

The genus is named in honor of Mr. N. Ingram Hendey of the British Museum (Natural History) in recognition of his great work on "The Plankton Diatoms of the southern Seas; Discovery Reports, vol. 16, 1937, pp. 151–364, pls. 6–13.

Genotype, *Hendeya dehiscens* L. F. and S., n. sp.

HENDEYA DEHISCENS Long, Fuge and Smith, n. sp.
Plate 18, figure 16

Valve elliptical; surface sloping in a gentle curve from center to circumference; markings consist of close, finely marked striae running irregularly from an undifferentiated center. Near each extremity of the valve and at the border is a small circular hyaline space with a tiny central nodule apparently analogous to the ocelli of such forms as *Eupodiscus* or *Auliscus* and opposite each of these there is a short blunt spine. Length, .10; width, .065 mm.

The paratype is somewhat less elongate than the holotype and the margin is nearly perfect. It measures, length, .050; width, .042 mm.

Holotype, No. 3446; paratype, No. 3447.

HUTTONIA CRETACEA Long, Fuge and Smith, n. sp.
Plate 17, figure 9

Valve narrowly elongate, with a series of fine closely spaced transverse wavy lines and two heavy internal bars across the midsection; ocelli large and apparently nearly circular, placed near each end and 180 degrees apart. Length, .080, width, .0234 mm.

This strange species is not so twisted on an axis perpendicular to the plane of the valve as *H. alternans* Grove and Sturt (1887, p. 142) and does not possess the fine, rather widely spaced puncta of that form. It bears even less resemblance to the coarsely punctate *H. reichardtii* Grunow (1863, pl. 4, fig. 22; Leuduger-Fortmorel, 1898, pl. 8, fig. 23; Rampi, 1938, pp. 88–90) living along the Mediterranean and African coasts and originally referred to *Cerataulus*.

Holotype, No. 3408.

KENTRODISCUS BLANDUS Long, Fuge and Smith, n. sp.
Plate 19, figures 3, 4, 5
(Pl. 18, fig. 14?)

This *Kentrodiscus* differs from the other species of the genus chiefly by the presence of the thorny processes which are generally associated with it. Moreover, even with a high power we are not able to distinguish any markings.

While we hold the view that *Kentrodiscus* consists, probably, of the spores of another genus, we deem it wise to report the presence of this form which occurs along with the more usual species, *K. andersoni* Hanna. Diameter, .035, length, .070 mm.

Holotype, No. 3409, paratypes, Nos. 3410, 3411.

On plate 18, figure 14 we have given a photograph of a diatom from the same series of slides as the above; it seems doubtful if this may be a lower valve of *K. blandus* but we have not been able to place it satisfactorily elsewhere. The spines are not grouped centrally but until more information is available it seems best to leave it with this species.

KITTONIA HANNAI Lefébure and Chenevière
Plate 19, figures 6, 7

Kittonia hannai Lefébure and Chenevière, 1939, Soc. française Micro. Bull., vol. 8, no. 1, p. 23, pl. 1, fig. 3.

Valve triangular with slightly convex sides, about .02 mm., from angle to angle. The sides rise somewhat sharply for a short distance, bearing rows of alveoli arranged at right angles to the margin. The central area is almost flat, and the rows of alveoli are continued towards a circular, hyaline center, marked by a few scattered pearls or short lines irregularly placed. Near each angle is a small circular, hyaline space from the center of which rises gently a long, slender, tubular process, boldly curved, and terminating in a trumpet-shaped mouthpiece; the terminal surface having a number of small scattered dots.

The first specimens of this diatom were found by Mons. E. Chenevière, the French diatomist, in Moreno shale material sent to him by Dr. Hanna.

The illustrations are drawings by Mr. N. Ingram Hendey, F.R.M.S., from a specimen in the possession of Mr. H. Potter of Birmingham. The above description is from the same specimen. The holotype is supposed to be in the collection assembled by M. Chenevière. The length of one side of it was given as 60 microns.

LEPIDODISCUS sp.
Plate 17, figure 13

We publish a view of what is apparently a fragment of a new species of *Lepidodiscus*. Unfortunately the specimen is incomplete, consisting only of a portion of a "plate" or layer of one of these rare and complex valves.

This, the first noted presence of such a form in an American deposit, is of great interest and affords another reason for relating the Moreno formation with those ancient deposits in Russia with which this genus is usually associated (Schmidt, 1886, pl. 103, fig. 5; Van Heurck, 1896, p. 499; Karsten, 1928, p. 220).

Since the fragment is incomplete we give the reproduction of the photograph, but do not feel justified in attempting to describe it or to create a new species therefor, but wait in hope for the discovery of a perfect valve. Diameter, .095 mm.

Hypotype, No. 3412.

LITHODESMIUM CALIFORNICUM Grunow

Lithodesmium californicum Grunow in Van Heurck, 1883, Syn. Diat. Belgique, pl. 115, fig. 9.—Schmidt, 1890, Atlas, Diat., p. 159, fig. 11.

This form, of which we have observed a number of specimens is by no means rare in certain samples. It seems to carry somewhat larger markings than does the type.

LITHODESMIUM MARGARITACEUM Long, Fuge and Smith, n. sp.
Plate 17, figure 16

Valve triangular; surface flat save for the large triangular bosses which are well raised. The markings consist of pearls which are closely set and which flow in distinct radiating lines from a small clear center to the uppermost part of the bosses. Close to the center is the well-marked scar marking the site of the typical rod of *Lithodesmium*.

This form bears a distinct resemblance to the *T. undulatum* of Ehrenberg, illustrated by Van Heurck (1883, pl. 116, fig. 7) and which comes from Maryland. This also may be the *L. undulatum* of the same plate (figs. 8, 12). The Moreno form has, however, larger and differently shaped bosses, and more clearly marked pearls. Length, angle to angle .090 mm.

Holotype, No. 3413.

MAMMIDION Long, Fuge and Smith, n. gen.

Valves disciform; outer portion flat, divided into radial segments; inner portion rising to a mammiform protuberance.

Genotype: *Mammidion elegans*, n. sp.

MAMMIDION ELEGANS Long, Fuge and Smith, n. sp.
Plate 17, figure 4

Valve circular, flat for almost two-thirds of the diameter, when a notable mammiform protuberance rises to a flat center. The hyaline center bears a few scattered puncta and is surrounded by three or four irregular rows of large beads. The flat portion of the valve is divided into about twenty rectangular sections by narrow, hyaline, radial

channels; each section has subradial and subconcentric rows of large pearls; outside the sections a ring of close-set pearls somewhat oval in shape and a definite border line separate the compartments from a finely striated hyaline margin. Diameter, .060 mm.

Whilst this valve is somewhat coscinodiscoid in type, the fact of its unusual contour and also the possession of markings of four different types or sizes seems to justify the creation of a new genus for its reception.

Holotype, No. 3414.

MELOSIRA (?) DENS-SERRAE Long, Fuge and Smith, n. sp.
Plate 17, figure 12

Valve circular, surface almost flat. There is a prominent, hyaline border, which apparently curves to the outer edge. This border is about one-tenth of the diameter of the valve in breadth. The central portion of the valve overlaps the border in an irregular manner giving the suggestion of a toothed wheel; this portion consists of two layers; the upper shows about twelve short narrow bars or costae about .005 mm. long placed at regular intervals on the outer edge and pointing towards the center; these bear evident puncta and a number of large clear spots arranged more or less subconcentrically. The lower layer shows numerous, crowded, fine, dotted striae arranged radially and reaching the center.

This diatom has evident affinity with *Melosira*, in which genus we leave it at present. Diameter, .050 mm.

Holotype, No. 3415.

MELOSIRA PATERA Long, Fuge and Smith, n. sp.
Plate 17, figure 18

Valve circular; flat at border for about one-fifth diameter, where there is a short, sharp rise to an almost flat center. At the border are a number of short lines, separated .005 mm. to .01 mm., irregular in direction, but all more or less pointing towards the center. The middle portion of the disk presents a few clear spots. The general impression of the valve is of a hyaline disk resembling an undecorated, white porcelain dinner plate. Diameter, about .010 mm.

This diatom is fairly common in some strata, but is evidently delicate for an uncracked valve has not been noted.

Holotype, No. 3416.

METROSULUS GRACILIS Hanna

Metrosulus gracilis Hanna, Calif. Acad. Sci. Oc. Pprs. 13, 1927, pl. 3, figs. 9, 10.

This form appears very sparsely in the material at our disposal.

MONOPSIA MAMMOSA Grove and Sturt
Plate 18, figure 1

Monopsia mammosa Grove and Sturt, 1887, Quekett Micr. Club Journ., ser. 2, vol. 3, p. 141, pl. 13, fig. 38.—Schmidt, Atlas, Diat. pl. 125, figs. 14, 15.

The form discovered in the shale differs from that described and illustrated by Grove and Sturt only in the marking of the circular process. Grove and Sturt describe the marks as consisting of two rings of large dots. In our specimen there is a ring of radial striae extending halfway to the center which is irregularly dotted.

But since there is variety in the markings of the Oamaru specimens, some of which certainly carry striae upon the process, we do not regard it necessary to separate this form in any way from the type.

Considerable interest is attached to the discovery of this form, which until recently was associated only with the New Zealand deposit, the more so since M. Chenevière (1934, p. 106) has recently described a closely allied form, *M. marginata*, found by him in the Russian deposit of Kamichev.

Hypotype, No. 3417.

PLANKTONELLA (?) CALIFORNICA Long, Fuge and Smith, n. sp.
Plate 17, figure 10

Valve circular, surface almost flat. The markings consist of distinct beads arranged at the margin in radial rows of two, three or four beads. Within this area the beads, even in size, are sparsely and irregularly scattered over a finely reticulated surface. From the outer ends of the rows, spines are attached which protrude radially and regularly outwards, in length about one

tenth of the diameter of the valve. Diameter, .050 mm.

It is only with hesitation that we have referred this curious valve, of which only one specimen has been observed, to *Planktonella*.

Holotype, No. 3418.

PODOSIRA MIRABILIS Long, Fuge and Smith, n. sp.
Plate 17, figure 5

The general appearance of the valve corresponds to such a form as *P. argus*, with well-marked border and broad ring surrounding a clear center. Here the center is broad and subhyaline, surrounded by a wide-arched ring which is provided with large radial spines inserted mainly on the inner margin of the ring and reaching wholly or partly across it. These spines appear to lie on the diatom until their end is reached when the apex can be seen, with a high power, to be lifted slightly above the body of the valve. At the outer edge of the ring another row of shorter spines is directed outwards over the hyaline margin. Diameter, .0425 mm.

Holotype, No. 3419.

PODOSIRA SUPERBA Long, Fuge and Smith, n. sp.
Plate 19, figure 1

This diatom is akin to *P. mirabilis* described above, but we regard the differences as sufficient to warrant the creation of a new species.

Valve circular; center large and circular, hyaline, the inner portion irregularly and sparsely dotted with coarse beads and distinct from the outer portion. Outside this is a narrow, radially striated ring with numerous coarse beads, chiefly on the outer edge; surrounding this is another wide ring covered with fine, decussate markings bearing coarse knobbed protuberances on the outer edge and falling sharply to a narrow hyaline rim. Diameter, .085 mm.

Holotype, No. 3420.

PODOSIRA SUPERBA RETICULATA Long, Fuge and Smith, n. var.
Plate 19, figure 2

In the variety *reticulata* the whole of the central hyaline portion, with the exception of the dotted middle, is broken up into irregular compartments by narrow channels which afford the most striking feature of the valve. Diameter, .088 mm.

Holotype, No. 3421.

PORPEIA sp.
Plate 17, figure 11

Quadrangular in girdle view with rounded edges. The valves are oblong with strong puncta closely arranged towards the angles but more distant in the median portion. Internal septa distinct. Girdle bearing transverse rows of parallel puncta. Length, .065, width, .0525 mm.

This is probably a new species, but in view of the importance of the valve aspect in this genus we prefer to leave it unnamed awaiting the finding of the necessary specimen.

Hypotype, No. 3422.

RHAPHIDOPHORA Long, Fuge and Smith, n. gen.

Valve circular, divided into segments alternately raised and depressed; segments punctate in parallel lines.

Genotype, *Rhaphidophora elegans*, n. sp.

RHAPHIDOPHORA ELEGANS Long, Fuge and Smith, n. sp.
Plate 17, figure 6

Valve circular; central area large and round with about twelve radial rows of four pearls each, and surrounded by a narrow hyaline ring. The outer portion of the diatom is divided into about twenty-four cuneate sectors, alternately raised and depressed, and varying alternately in width. The wider sectors have parallel and concentric lines of pearls; the narrower ones have a median line of five or six pearls running from the margin halfway to the hyaline ring. Diameter, .033 mm.

This diatom has been described from what is apparently an upper "plate," but is so striking that we think it should be noted. Affinities to *Coscinodiscus* and *Actinoptychus* are evident.

Holotype, No. 3423.

STEPHANOPYXIS APPENDICULATA
Ehrenberg

Stephanopyxis appendiculata Schmidt, 1888, Atlas, Diato., pl. 130, figs. 18–26, 29–33; also *S. turris* Grunow, pl. 130, figs. 42, 43.—Mann, 1907, Cont. U. S. Nat. Herb., vol. 10, pt. 5, p. 244.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 32, pl. 4, fig. 9.

This diatom appears to be common in many of the samples. Rarely a small, stout and somewhat cylindrical form is to be noted, but the regular form greatly resembles that illustrated in the Atlas, pl. 120, fig. 35. In some samples the diatom reaches a considerable size and there may be distinguished from an accompanying form, which is only slightly larger, by the fact that *S. appendiculata* lacks any trace of border when observed in the valve aspect.

As the above references will indicate this form is very similar to *S. turris*, by which name it will be recognized by many, but we have chosen to follow Hanna and Schmidt, leaving the name *turris* for the diatom illustrated in the Atlas, pl. 130, figs. 42 and 43, which, though similar, is much more delicate. In his Index, Mills reverses the matter and refers all the forms to *turris*.

STEPHANOPYXIS BARBADENSIS Greville

Stephanopyxis barbadensis Greville, 1865, Trans. Micr. Soc. London, N. S., vol. 13, p. 3, pl. 1, fig. 11; (as *Creswellia*).—Schmidt, 1888, Atlas, Diat., pl. 130, figs. 6, 10.—Grove and Sturt, 1887, Journ. Quekett Micr. Club, ser. 2, vol. 3, p. 70.

Stephenopyxis corona, Van Heurck, 1882, Syn. Diat. Belgique, pl. 83, ter. figs. 10, 11.—Schmidt, 1888, Atlas, Diat., pl. 123, figs. 10, 17; pl. 130, 1888, figs. 16, 17, 36.

Examination of the references and figures cited above will reveal how great a confusion exists between these forms and how difficult it is to name one of these *Stephanopyxis* with confidence.

In certain of the Moreno samples there is found a *Stephanopyxis* of moderately large size, convex in contour, possessing a slight but very distinct rim or border and a circlet of spines of moderate stoutness. This agrees closely with Greville's illustration, save that the spines are somewhat longer than in the Moreno specimens.

STEPHANOPYXIS GRUNOWII
Grove and Sturt

Stephanopyxis grunowii Schmidt, 1888, Atlas, Diat., pl. 130, figs. 1, 4.

This distinctive form, though not plentiful, seems to be distributed throughout all of the samples studied.

STEPHANOPYXIS RETICULATA Long, Fuge and Smith, n. sp.
Plate 19, figure 8

Valve circular, the surface rising sharply from a fairly wide rim to a large convex central area. This area is finely dotted and overlaid with a coarse reticulum which affords a striking appearance. The outer edge of the conical area bears a ring of large conical spines. The border is very coarsely striated and bears an irregular ring of small beads on the inner edge. Diameter, .07 mm.

Holotype, No. 3443.

STEPHANOPYXIS RUDIS Greville
Plate 16, figure 9

Stephanopyxis rudis Schmidt, 1888, Atlas, Diat., pl. 164, fig. 9; pl. 123, 1891, figs. 16, 17, 20 (under the name of *S. corona* Grunow).

Reference to the forms cited above will illustrate the confusion in nomenclature referred to in the note under *S. appendiculata*.

We have preferred the name of *rudis* to *corona* as, while the form in question *may* be an under valve of *corona*, it is not the diatom we understand to be popularly recognized by that name.

Hypotype, No. 3424.

STICTODISCUS CONCINNUS Long, Fuge and Smith, n. sp.
Plate 17, figure 14

Valve circular, with slight central depression; border of prominent, regular, polygonal areolae. Within the border are short radial rows disposed in pairs, these rows each of three or four puncta, and each pair separated from the next by a single punctum close to the border. The central portion has larger puncta sparsely scattered in an irregularly concentric manner. Diameter, .040 mm.

Holotype, No. 3425.

STICTODISCUS GROSSEPUNCTATUS Long, Fuge and Smith, n. sp.
Plate 18, figure 15

Valve triangular with gibbous sides, surface flat, sparsely and irregularly provided with pearls. These are smaller, rounded, and distant in the central area, larger, closer and generally elongated towards the margin.

This diatom presents a distinct resemblance to *Triceratium hertleini* but has neither the processes nor markings of *Triceratium* in the angles. Length from angle to angle, .0725 mm.

Holotype, No. 3426.

TERPSINOE ANGUINEA Long, Fuge and Smith, n. sp.
Plate 16, figure 3

Zonal view oblong, divided into three segments by septa which are curved and thickened at the ends in a manner suggestive of the conventional representation of an asp. Surface punctate; the puncta of the middle segment being coarser and sparse. Length, .046, width, .035 mm.

Holotype, No. 3427.

TRICERATIUM ALBUM Long, Fuge and Smith, n. sp.
Plate 18, figure 7

Valve triangular with perfectly straight sides. The center of the valve is raised presenting the figure created by the union of three narrow crescents; remainder of surface flat save that the well-marked bosses rise to the level of the central area. The markings consist of pearls; those on the raised central area being small and widely scattered; those on the flat portion being arranged subradially or in rows disposed across the angles. At the margin, larger markings suggest incipient costae. The bosses are distinctly marked in close decussating lines. Length of side, .1175 mm.

This diatom is very similar to that illustrated by Schmidt (1886, pl. 112, fig. 3) and called *T. exornatum* Greville, var. *robusta* Witt, which is much more strongly marked than the type form. Both are from Archangel, and both are quite flat. We have been disposed to make this a Californian variety of *T. exornatum*, but having regard to the considerable difference from the type form, both in marking and contour we have

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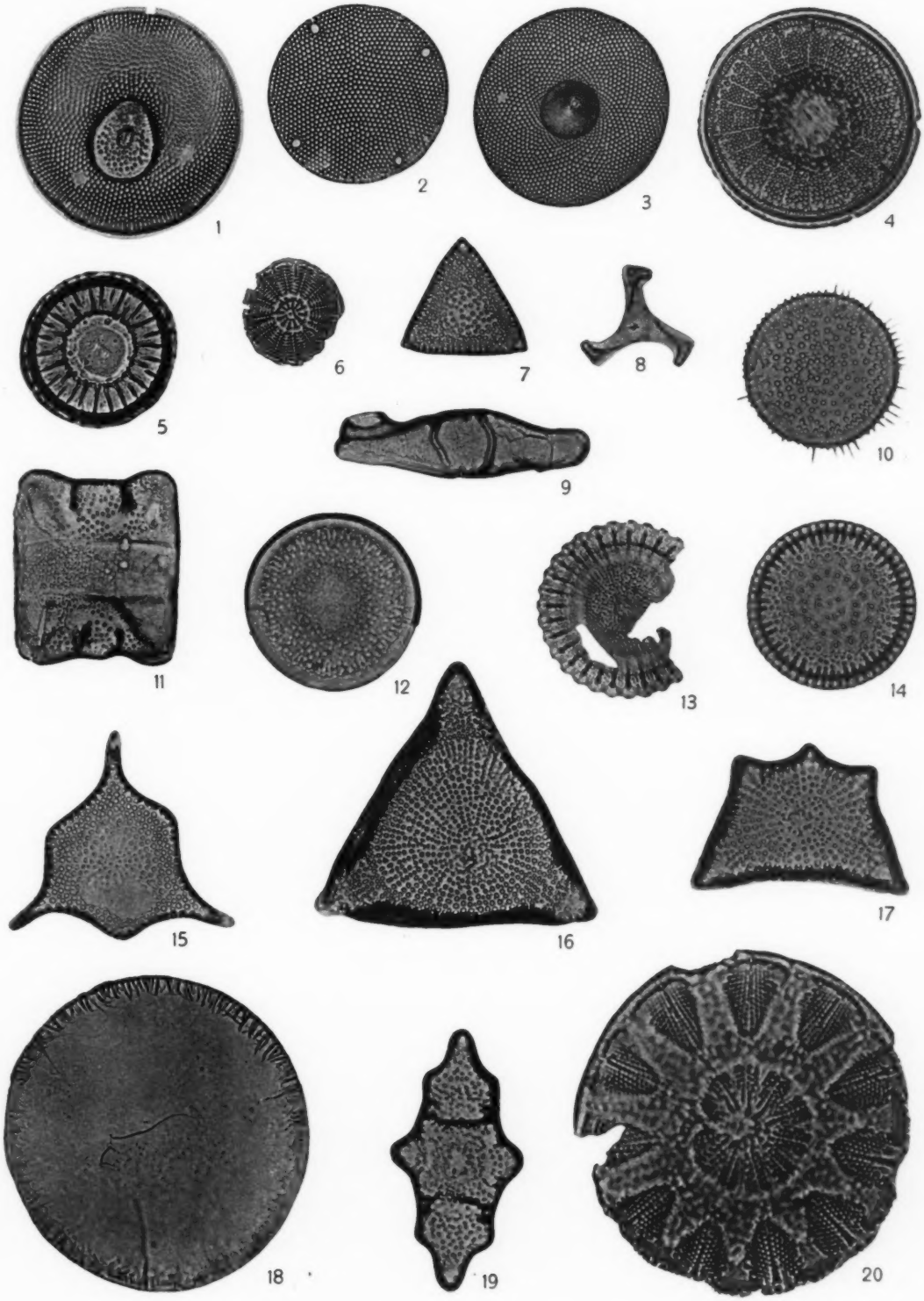
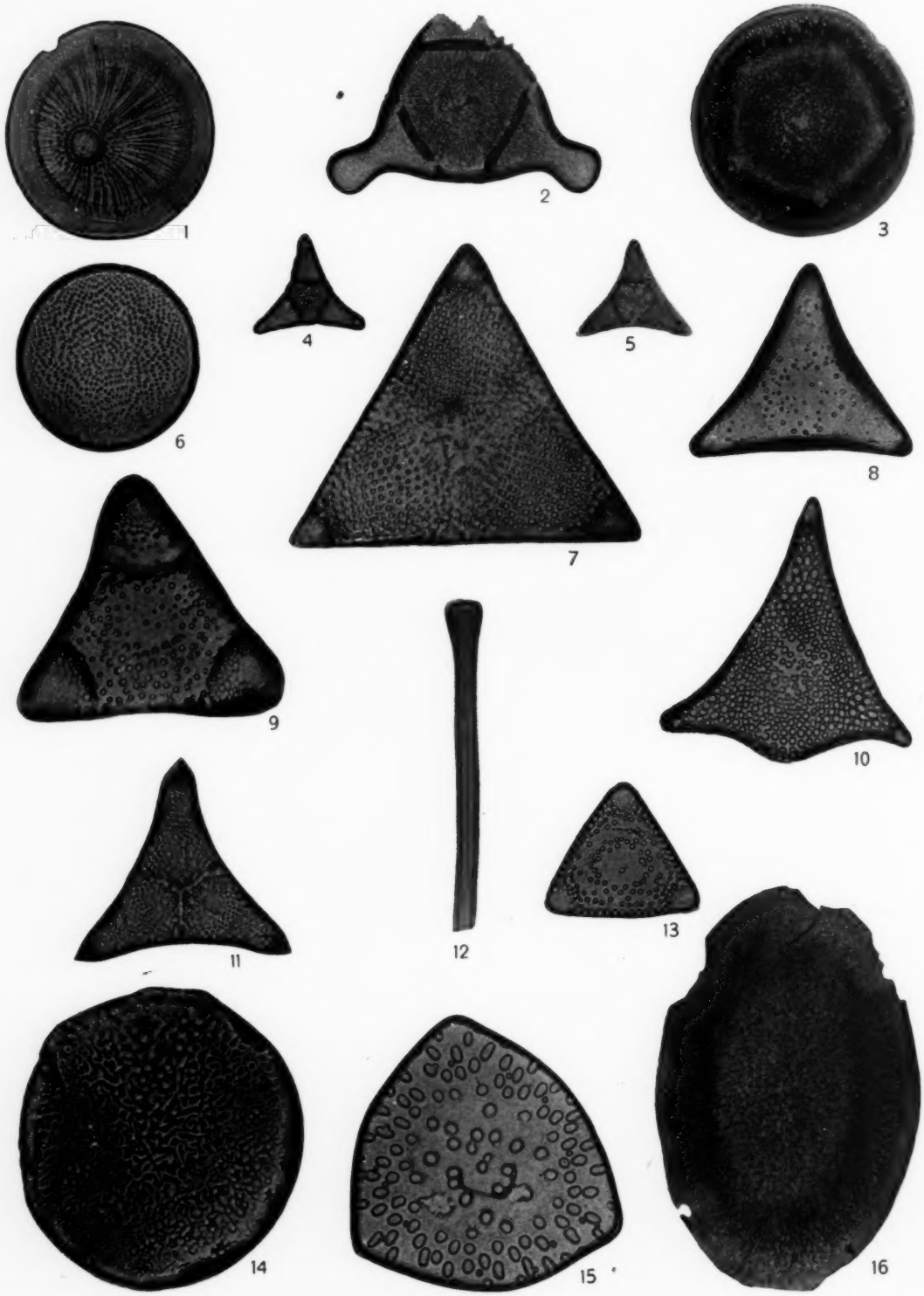
EXPLANATION OF PLATE 17

FIGS. *1*—*Craspedodiscus morenoensis* Long, Fuge and Smith, n. sp. Holotype, Diam., .072 mm. (p. 105)
2—*Eupodiscus radiatus* Bailey. Diam., .112 mm. (p. 107)
3—*Coscinodiscus morenoensis* Hanna. Diam., .125 mm. (p. 104)
4—*Mammidion elegans* Long, Fuge and Smith, n. gen. and n. sp. Holotype, Diam., .060 mm. (p. 108)
5—*Podosira mirabilis* Long, Fuge and Smith, n. sp. Holotype, Diam., .0425 mm. (p. 110)
6—*Rhaphidophora elegans* Long, Fuge and Smith, n. gen. and n. sp. Holotype, Diam., .033 mm. (p. 110)
7—*Trinacria nitescens* Long, Fuge and Smith, n. sp. Holotype, Length of side, .033 mm. (p. 116)
8—*Triceratium swastika* Long, Fuge and Smith, n. sp. Holotype, Length of side, .05 mm. (p. 114)
9—*Huttonia cretacea* Long, Fuge and Smith, n. sp. Holotype, Length, .080, width, 0234 mm. (p. 107)
10—*Planktoniella ? californica* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 109)
11—*Porpeia* sp. Hypotype, Width, .0525, length, .065 mm. (p. 110)
12—*Melosira ? dens-serrae* Long, Fuge and Smith, n. sp. Holotype, Diam., .050 mm. (p. 109)
13—*Lepidodiscus* sp. (p. 108)
14—*Stictodiscus concinnus* Long, Fuge and Smith, n. sp. Holotype, Diam., .040 mm. (p. 111)
15—*Triceratium dignum* Long, Fuge and Smith, n. sp. Paratype, Length of base, .069 mm. (p. 113)
16—*Lithodesmium margaritaceum* Long, Fuge and Smith, n. sp. Holotype, Length of side, .090 mm. (p. 108)
17—*Triceratium perplexum* Long, Fuge and Smith, n. sp. Holotype, Length, long side, .070 mm. (p. 114)
18—*Melosira patera* Long, Fuge and Smith, n. sp. Holotype, Diam., .010 mm. (p. 109)
19—*Biddulphia primordinalis* Long, Fuge and Smith, n. sp. Holotype, Length, .1254 mm. (p. 101)
20—*Upothema californica* Long, Fuge and Smith, n. gen. and n. sp. Holotype, Diam., .0375 mm. (p. 117)

All specimens from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms



Long, Fuge and Smith—Cretaceous Diatoms

decided to create a new species, but its relationship to the forms referred to is very close.

Holotype, No. 3428.

TRICERATIUM BELLUM Long, Fuge and Smith, n. sp.
Plate 18, figure 13

Triangular, sides almost straight, angles rounded; bosses with radial lines of fine beads; central hyaline space surrounded by an irregular ring of beads, other scattered beads outside this ring, and a row of large beads close to each side of the diatom. Length of side, .040 mm.

Holotype, No. 3429.

TRICERATIUM BICORNIGERUM Hanna

Triceratium bicornigerum Hanna, 1927, Calif. Acad. Sci. Oc. Pprs., 13, p. 34, pl. 4, figs. 13, 14.

This diatom is fairly plentiful in certain samples.

TRICERATIUM CELLULOSUM CALIFORNICUM Long, Fuge and Smith, n. var.
Plate 18, figure 9

The Moreno form is very close to that illustrated by Schmidt (1886, pl. 112, fig. 4) as var. *simbirskiana* Witt, but the sulci are not free from beads as shown in that figure. Length of side, .070 mm.

Here again there is a noteworthy relationship to the Russian fossils.

Holotype, No. 3430.

TRICERATIUM DIGNUM Long, Fuge and Smith, n. sp.
Plate 17, figure 15; plate 18, figure 10

Triangular, with very acute angles, the middle of each side strongly swollen; bosses small and finely dotted; valve covered with coarse, radial puncta becoming irregular and less definitely marked towards the center. Length of side, .070 mm.

The description pertains to the holotype. Variation is such that two sides may become definitely convex as in the paratype.

Holotype, No. 3431, paratype, No. 3432.

TRICERATIUM HERTLEINI Hanna

Triceratium hertleini Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 35, pl. 4, fig. 15.

This diatom which has angles so marked as to place it with *Triceratium* has also many affinities with the genus *Stictodiscus*. It is by no means rare in the Moreno Shale.

EXPLANATION OF PLATE 18

FIGS. *1*—*Monopsia mammosa* Grove and Sturt. Diam., .055 mm. (p. 109)
2—*Triceratium pruinosum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .088 mm. (p. 114)
3—*Aulacodiscus morenoensis* Long, Fuge and Smith, n. sp. Holotype, Diam., .080 mm. (p. 98)
4, 5—*Trinacria deciusi* Hanna, var. *summaria* Long, Fuge and Smith, n. var. *4*, Holotype, Length of base, .055 mm.; *5*, Same specimen different focus. (p. 116)
6—*Coscinodiscus inordinatus* Long, Fuge and Smith, n. sp. Holotype, Diam., .060 mm. (p. 103)
7—*Triceratium album* Long, Fuge and Smith, n. sp. Holotype, Length of base, .1175 mm. (p. 112)
8—*Triceratium lustratum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .068 mm. (p. 114)
9—*Triceratium cellulosum* Grove and Sturt, var. *californicum* Long, Fuge and Smith, n. var. Holotype, Length of base, .070 mm. (p. 113)
10—*Triceratium dignum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .064 mm. (p. 113)
11—*Trinacria interlineata* Long, Fuge and Smith, n. sp. Holotype, Length of base, .070 mm. (p. 116)
12—*Tubularia pistillaris* Brun, var. *grossepunctata* Long, Fuge and Smith, n. var. Holotype, Length, .11 mm. (p. 116)
13—*Triceratium bellum* Long, Fuge and Smith, n. sp. Holotype, Length of base, .04 mm. (p. 113)
14—*Kentrodiscus blandus?* Long, Fuge and Smith, n. sp. Paratype, no. 3411*a*, Diam. .086 mm. (p. 107)
15—*Stictodiscus grossepunctatus* Long, Fuge and Smith, n. sp. Holotype, Length of base, .0725 mm. (p. 112)
16—*Hendeya dehiscens* Long, Fuge and Smith, n. g., n. sp. Holotype, Length, .10, width, .065 mm. (p. 107)

All specimens illustrated from Sec. 24, T. 14 S., R. 11 E., M.D.M., Fresno County, California.

TRICERATIUM LUNATUM Long, Fuge and Smith, n. sp.
Plate 16, figure 2

Shaped like a crescent moon, five days old. From the dorsal side to a small hyaline space near the vertical border run radial or sub radial rows of beads gradually decreasing in size. The angles slightly raised with a number of fine beads irregularly arranged. Length, .080 mm.

This form is closely related to *T. semicirculare* as figured by Brightwell (1853, p. 252) and Wolle (1890, pl. 105, figs. 2, 4) but in our specimen the bosses in the angles and the channels separating them from the central portion are very obscure or missing.

Holotype, No. 3433.

TRICERATIUM LUSTRATUM Long, Fuge and Smith, n. sp.
Plate 18, figure 8

Valve triangular with sides slightly concave, angles narrowly rounded and finely dotted; surface bright, bearing irregular puncta. Length across base, .068 mm.

Holotype, No. 3434.

TRICERATIUM PERPLEXUM Long, Fuge and Smith, n. sp.
Plate 17, figure 17

Valve irregularly pentagonal, one angle occupying each end of the base line; the other three angles approaching each other in the area of what would be the apex of a normal triangle. A small clear central space is surrounded by an irregular circle of small dots whence radiating lines of larger puncta proceed to the valve edge. In the specimen examined the dots on the processes do not correspond, those on the two lower processes being smaller than those of the three upper. Length, .070, width, .040 mm.

Several specimens of this diatom have been seen; otherwise, we might feel inclined to regard it an anomalous form.

Holotype, No. 3436.

TRICERATIUM PRUNINOSUM Long, Fuge and Smith, n. sp.
Plate 18, figure 2

Valve triangular with convex sides and angles produced into large rostrate-capitate protuberances. Radial rows of fine beads run from the angles to incomplete lines or furrows which mark off a central triangle; within this, slightly coarser rows of dots run radially to the center. Length of side, 088. mm.

This diatom is possibly out of place in the genus *Triceratium;* it shows affinities with *Hydrosera*. But having only this incomplete form to work with we are leaving it in *Triceratium* which contains many forms that will probably sometime be removed to other genera.

Holotype, No. 3435.

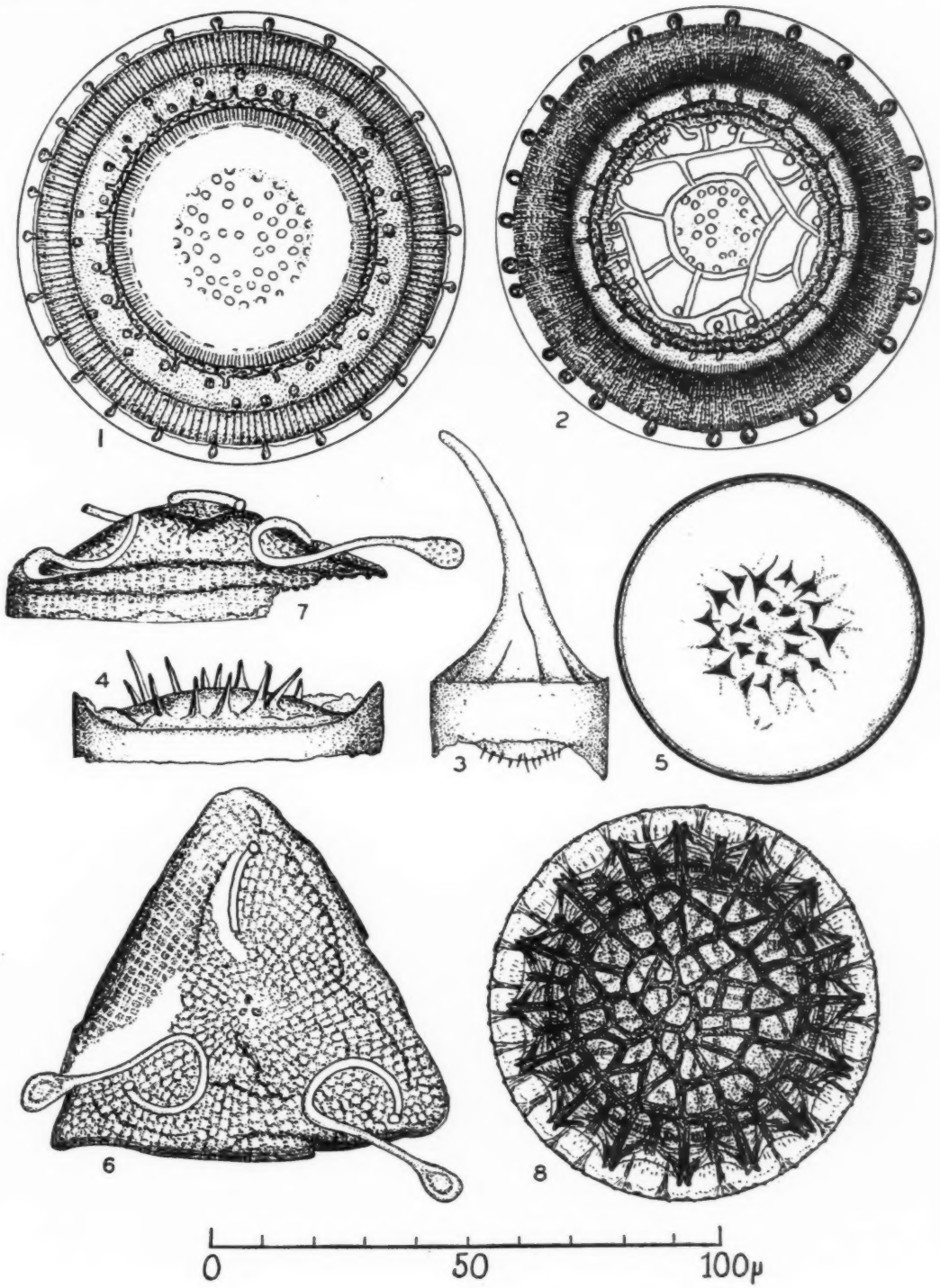
TRICERATIUM SWASTIKA Long, Fuge and Smith, n. sp.
Plate 17, figure 8

Valve triangular with deeply concave sides and arms twisted over at right angles with very protuberant bosses; center depressed, round, hyaline, and surrounded by concentric rows of pearls. Distance from angle to angle .05 mm.

Holotype, No. 3437.

PLATE 19

FIGS. *1—Podosira superba* Long, Fuge and Smith, n. sp. Holotype, Diam., .088 mm. (p. 110)
2—Podosira superba var. *reticulata*, Long, Fuge and Smith, n. var. Holotype, Diam., .088 mm. (p. 110)
3—Kentrodiscus blandus Long, Fuge and Smith, n. sp. Holotype, Diam., .035, length, .070 mm. (p. 107)
4, 5—Kentrodiscus blandus Long, Fuge and Smith, n. sp. Paratypes, Nos. 3410, 3411. Length, (fig. 4), .060 mm. Diam. (fig. 5), .060 mm. (p. 107)
6, 7—Kittonia hannai Lefébure and Chenevière. Specimen in the collection of Mr. H. Potter, Birmingham, England. (p. 108)
8—Stephanopyxis reticulata Long, Fuge and Smith, n. sp. Holotype, Diam., .0736 mm. (p. 111)
All specimens except figs. 6 and 7 from Sec. 24, T. 14 S., R. 11 E., M.D.M. Fresno County, California.



Long, Fuge and Smith—Cretaceous Diatoms

TRINACRIA ARIES Witt

Trinacria aries Schmidt, 1890, Atlas, Diat., pl. 150, figs. 14, 15.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 36, pl. 5, figs. 1, 2.

This form is abundant in the Moreno formation.

TRINACRIA DECIUSI SUMMARIA Long, Fuge and Smith, n. var.
Plate 18, figures 4, 5

Valve triangular with sides concave, angles acutely rounded; central area nearly hexagonal, deeply depressed from the plane of the arms, and bounded by heavy dark lines; entire surface covered with closely set fine beads in rows which radiate out from the center; "spines" or horns at the angles apparently low and flat on top.

This form seems well characterized by the abundance and minuteness of the surface markings. The shape is almost identical to *T. deciusi* Hanna, but the two specimens of that species which have been illustrated bear very coarse beads, widely spaced. This group of diatoms is very abundant in the Moreno shale and it may well be that the present form is merely a finely sculptured variant of that which is usually seen.

Holotype, No. 3440.

TRINACRIA INSIPIENS Witt

Trinacria insipiens Witt, 1886, Verh. Russ. Kais. Min. Gesell. St. Petersburg, ser. 2, vol. 22, p. 172, pl. 10, fig. 1; pl. 11, figs. 5, 7, 11; pl. 12, fig. 2.—Schmidt, 1886, Atlas, Diat., pl. 97, fig. 16; 1886, pl. 110, figs. 11, 13; 1886, pl. 111, figs. 24, 25.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 37, pl. 5, figs. 7, 8, 9.

By no means uncommon in some samples.

TRINACRIA INTERLINEATA Long, Fuge and Smith, n. sp.
Plate 18, figure 11

Valve triangular with slightly concave sides; angles pointed with triangular elongated processes. A small hyaline center is surrounded with radial lines of beads. Between this central area and the processes are elevated areas with beads irregularly placed. From the center, three prominent, narrow channels with dark borders run to the middle of the sides, and three similar, but less striking channels start near the center and run towards the angles. Length of side, .070 mm.

At first sight this form has a striking resemblance to *Lithodesmium margaritaceum* but close examination of valve and girdle views shows that the two are essentially different.

Holotype, No. 3438.

TRINACRIA MUCRONATA Schmidt

Trinacria mucronata Schmidt, 1886, Atlas, Diat., pl. 11, figs. 1, 2.—Hanna, 1927, Calif. Acad. Sci. Oc. Pprs. 13, p. 38, pl. 5, figs. 10.

Found in company with other species of the genus.

TRINACRIA NITESCENS Long, Fuge and Smith, n. sp.
Plate 17, figure 7

Valve triangular with sides slightly convex, and central portion somewhat raised; markings consist of coarse beads, closely placed near the margin, and more sparsely distributed towards the center; processes at angles, rounded and rather short. Length of side from angle to angle, .033 mm.

Holotype, No. 3439.

TUBULARIA PISTILLARIS GROSSEPUNCTATA Long, Fuge and Smith, n. var.
Plate 18, figure 12

This fragment, which is obviously a member of Brun's Genus *Tubularia* (1894, p. 88; Van Heurck, 1896, p. 337) appears only to differ from the figure in having considerably heavier puncta; we do not think a new species is called for but note the variety as above.

The occurrence of this rare form, hitherto apparently known only from Oamaru, is worthy of careful note.

A fragment only has been found, the length of which is .11 mm.

Holotype, No. 3441.

UPOTHEMA Long, Fuge and Smith, n. gen.

Valves consisting of two layers; the lower actinoptychoid in character, with alternate raised and depressed segments; the upper layer apparently superimposed, reaching neither to the center nor the border.

Genotype, *Upothema californica*, n. sp.

UPOTHEMA CALIFORNICA Long, Fuge and Smith, n. sp.
Plate 17, figure 20

This valve appears to consist of two distinct layers; the lower is actinoptychoid in character, having 22 sectors alternately raised and depressed. The raised sectors possess a distinct clear line radiating from the center to the circumference and bearing a small process at the termination. The lower sectors end in a large subtriangular clear space the base of which is on the border and almost coincident in breadth with the termination of the sector. This space also bears a nodule or process; the upper layer consists of a superimposed ring whose inner circumference is a third of the diameter from the center, and from which proceed eleven starfish-shaped arms, which terminate well within the body of the valve at the apex of the triangular spaces already referred to. The markings consist of puncta arranged on the sectors in a pinnate manner in reference to the pseudoraphe and the starfish arms. Diameter, .0375 mm.

Only one valve has been noted.

Holotype, No. 3442.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 2, PP. 119–129, PLS. 20–21, 1 TEXT FIG., MARCH 1946

UPPER JURASSIC OSTRACODA FROM THE COTTON VALLEY GROUP IN NORTHERN LOUISIANA; THE GENUS HUTSONIA[1]

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ABSTRACT—The new ostracode genus *Hutsonia* from the Cotton Valley group in northern Louisiana is described, together with seven new species and one new variety belonging to it.

INTRODUCTION

A SMALL faunule occurring in definitely marine strata of the Cotton Valley group in northern Louisiana provides our first knowledge of marine Jurassic Ostracoda in North America (1). Most of the ostracode genera found in the Cotton Valley appear to be new, and the present article is the first of a series describing Jurassic Ostracoda from the Gulf Coastal area. The writer's work has been supported by the U. S. Geological Survey and the type specimens are to be deposited in the U. S. National Museum.

The stratigraphy of the Upper Jurassic strata of the northern Gulf Coastal Plain has been described by W. B. Weeks (2) and R. W. Imlay (3, 4). The uppermost of the Jurassic strata, the Cotton Valley group, have been the subject of a separate stratigraphic study by Swain (5).

Paleontological contributions by Imlay (3, 4, 6) and Wells (7) on the macrofossils occurring in the marine pre-Trinity rocks of the area serve to establish present ideas as to the age relationships of these beds. Ostracoda and Foraminifera occur in the sequence, but have not been formally described. Some preliminary identifications of microfossils occurring in beds of the Cotton Valley group were published by L. W. Calahan (8).

The oldest rocks so far penetrated by drilling in northern Louisiana consist of dark shale, sandstone and limestone, at present designated by the preoccupied name, Morehouse shale (3, p. 7). The sequence has been encountered in only one well, that of the Union Producing Company, Tensas Delta Lumber Company no. A-1, Morehouse Parish, Louisiana. The Morehouse was at first thought to be Jurassic, but recent work by Imlay and Williams (9) has shown in it the presence of fossils believed to be late Paleozoic in age. No ostracodes have been reported from the Morehouse.

The Morehouse is overlain by a sequence of unfossiliferous red shale, sandstone and rock salt over 1200 feet thick, termed the Eagle Mills formation.

Overlying the Eagle Mills is the Smackover formation, limestone and dolomite, up to 1200 feet thick, which contains *Dichotomosphinctes*, *Discosphinctes* and other fossils, representing the Upper Jurassic Argovian stage, according to Imlay (10). The writer has no collections of ostracodes from the Smackover, although the dense limestone and shale layers which are present in parts of the formation may possibly contain such fossils.

The Smackover is overlain by the Buckner formation, comprising red shale, varicolored dolomite and anhydrite in southern Arkansas, northernmost Louisiana, and parts of northeastern Texas. To the south, the presumable equivalents of the Buckner are dark shales, interbedded with thin layers of argillaceous limestone. Species of the branchiopod crustacean *Estheria* have been identified by Imlay (6) from the red-bed parts of the Buckner, and *Ataxioceras*, a Lower Kimmeridgian ammonite, occurs in the offshore Buckner equivalents. The writer has obtained a species of the ostracode *Paracypris* from well-cuttings at the horizon of the Buckner in the Union Producing Company's McDonald no. A-1 well, Claiborne Parish, Louisiana, at a depth

[1] Published by permission of Director of Geological Survey, U. S. Department of the Interior.

of 11, 715–20 feet. The Buckner in this well is made up of red shale and anhydrite beds, which alternate with gray shales and thin layers of dolomite and oolitic limestone. The formation attains more than 500 feet in parts of northern Louisiana and northeastern Texas, but averages less than 300 feet.

The Cotton Valley group, as defined by Swain (5, p. 582), overlies the Buckner and underlies the basal Lower Cretaceous Hosston formation. The Cotton Valley group consists of two formations, the Bossier formation below and the Schuler formation above.

The Bossier formation, as typically developed in northern Louisiana, comprises dark shale, sandstone and limestone up to 2000 feet thick. Northward into southern Arkansas, and eastward into the Monroe structural platform of northeastern Louisiana, the Bossier passes into nearshore red beds. The red-bed facies of the Bossier is unfossiliferous, but in the offshore parts Imlay (10) has identified *Idoceras* cf. *I. durangense* Burckhardt, *Glochiceras* cf. *G. fialar* (Oppel) and *Aulacomyella* sp. These furnish a correlation with the Middle Kimmeridgian of Mexico. Ostracoda are not abundant in the Bossier formation. A number of poorly preserved Foraminifera have been obtained from cores in the type-section well, Bossier Parish, Louisiana. Among these Lozo (11) has tentatively identified a species of *Epistomina*.

The Schuler formation in the type area, Schuler oil field, Union County, Arkansas, consists of a lower sequence of red shale and red and white sandstone, named the Shongaloo member; above this lie pastel, varicolored shale and white sandstone, the Dorcheat member. The Dorcheat member attains more than 1200 feet, and the Shongaloo member slightly exceeds 1000 feet in maximum thickness. Down dip in northern Louisiana and northeastern Texas, the two members pass into offshore gray shale, sandstone and limestone, bearing abundant oysters and other invertebrates. Ostracoda occur in considerable numbers at certain horizons of the offshore beds of the Schuler. No recognizable fossils have been found in the nearshore red-bed parts of the Schyler, other than some Charophyta and carbonized plant remains, the latter occurring mostly as thin lignitic layers.

RELIABILITY OF DEPTH OF COTTON VALLEY WELL SAMPLES

The collections of Cotton Valley ostracodes include both those from well cores and those from rotary-well cuttings. The specimens from well cores may be considered to have fairly accurate depth connotation, at least within a few feet. Those from well cuttings, on the other hand, may have fallen from higher levels.

It is the custom among operators drilling to the deep-lying Jurassic rocks in northern Louisiana, to run casing through the younger beds to prevent various drilling difficulties. The danger of continuous contamination of Cotton Valley samples by material from Eocene and Upper Cretaceous strata is, thus, considerably lessened. The younger fossils occur, characteristically, in distinctive matrix and exhibit better preserved, more translucent shells than those in the Cotton Valley. Though a certain amount of contamination may result from recirculation of cuttings from the mud pits, this contaminating material, in most

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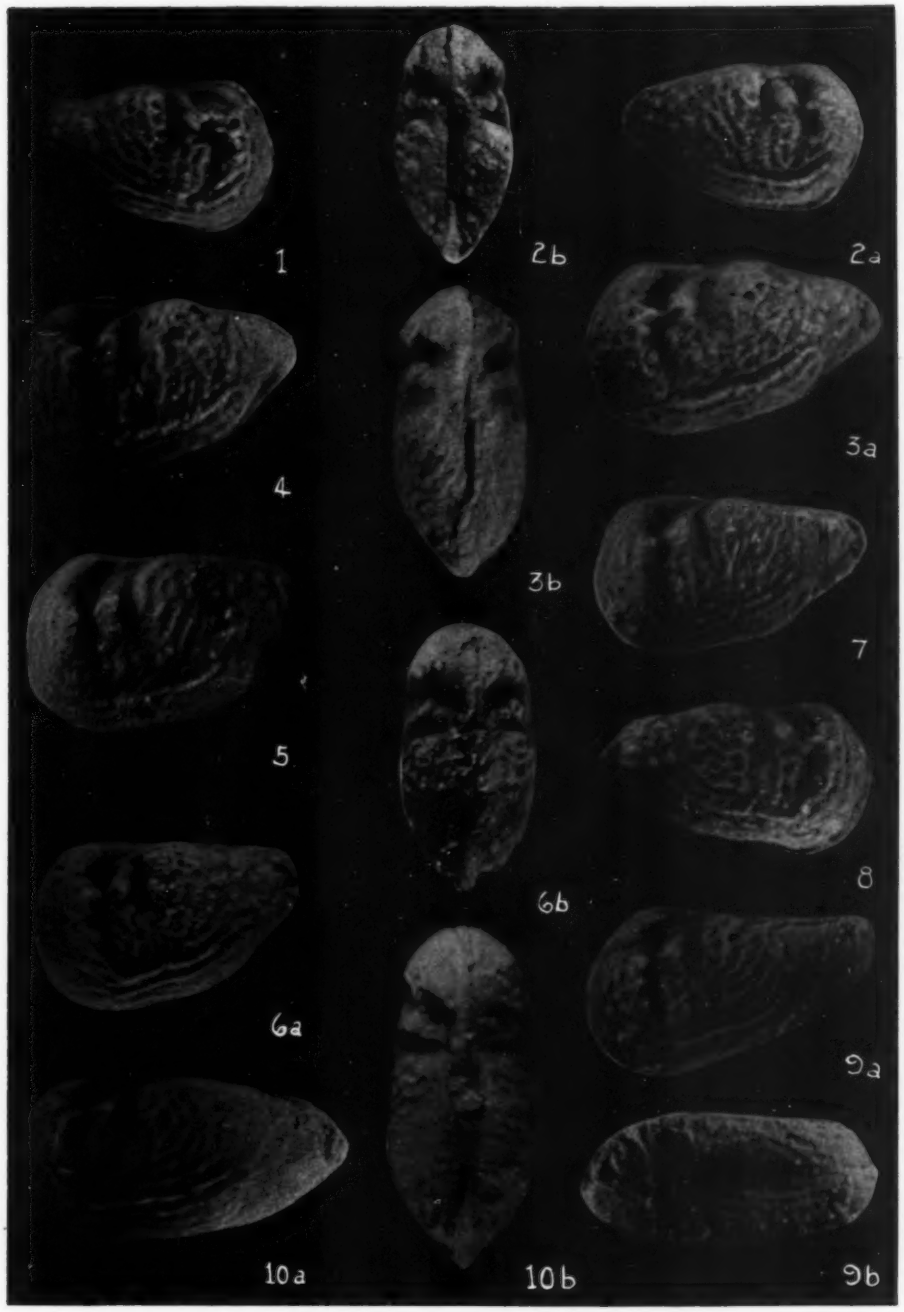
EXPLANATION OF PLATE 20

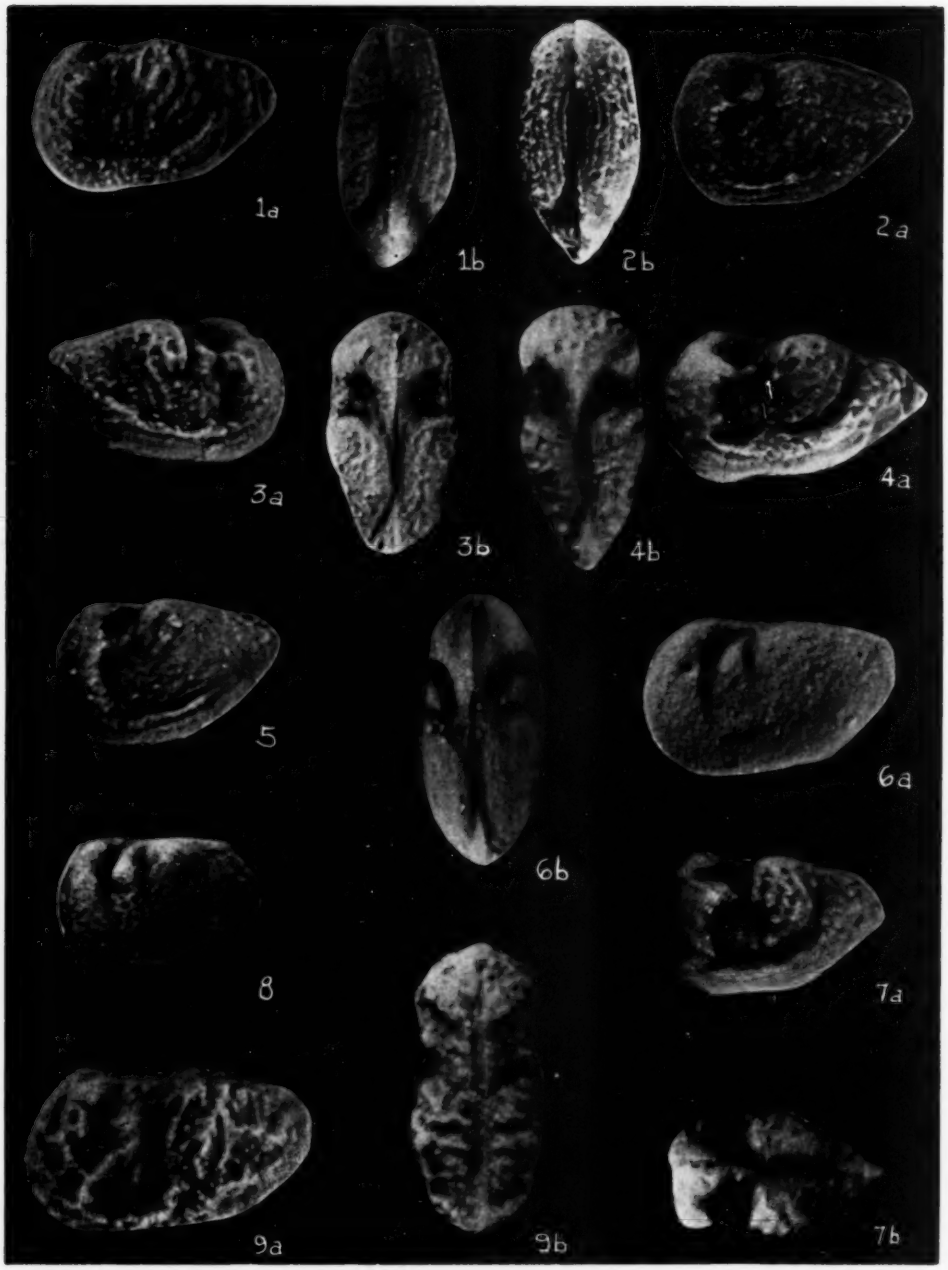
All figures approximately ×55

FIGS. *1–6—Hutsonia vulgaris* Swain, n. gen., n. sp. *1*, Right valve of a male; Morgan, Smith no. 2, 5063–81 feet. *2a–b*, Right valve and dorsal view of a male; Phillips, Kendrick no. 1, 5620–40 feet. *3a–b*, Left valve and dorsal view of holotype, a male; Phillips, Kendrick no. 1, 5620–40 feet. *4*, Left valve of a female (?); Phillips, Kendrick no. 1, 5620–40 feet. *5*, Left valve of a female; Phillips, Kendrick no. 1, 5620–40 feet. *6a–b*, Left valve and dorsal view of a female; Phillips, Kendrick no. 1, 5340–50 feet. (p. 124)

7–10—Hutsonia vulgaris var. *elongata* Swain, n. var. *7*, Left valve of a male; Phillips, Kendrick no. 1, 5440–50 feet. *8*, Right valve of a male; Humble, Bliss & Weatherby no. 30, 5260–61 feet. *9a–b*, Left valve and ventral view of a partly broken male; in *b* specimen arranged with right valve upward; Union, McDonald no. A-1, 10,555–60 feet. *10a–b*, Left valve and dorsal view of holotype, a female; Morgan, Smith no. 2, 5063–81 feet. (p. 125)



Swain—Jurassic Ostracodes



Swain—Jurassic Ostracodes

instances, may be easily recognized and disregarded.

The Lower Cretaceous Glen Rose formation, on the other hand, consists principally of shale, fossiliferous limestone and sandstone which is very similar in appearance to the offshore Cotton Valley sediments. Danger of confusion may result in cases where Glen Rose material caves into the Cotton Valley. The Glen Rose microfossils, are commonly better preserved than the older forms, and the two sequences are separated by 1500 feet or more of red beds of the Hosston formation. The material caving from higher levels is likely to be made up of fragments worn by drilling action, whereas the bottom-hole cuttings are more likely to appear freshly broken.

In order to prevent drilling difficulties, the operators necessarily keep the wall of the hole well mudded, and pump the well free of cuttings at frequent intervals, especially before and after running new bits and coring heads. The sample-catching machines used while drilling the wells are in most instances kept in proper adjustment and operation.

As a result of these considerations it is believed that, in general, microfossils obtained from Cotton Valley well samples are fairly accurate with respect to depth, although exceptions are known and are to be expected. It is hoped that when a zonation of Cotton Valley microfossils is accomplished, it will be based on well cores, but it may be necessary to rely in part on specimens from cuttings. The richest microfossil collections occur in the shales of the Cotton Valley, whereas for the most part, only the sandstones of the sequence are cored.

NATURE OF THE OSTRACODE RECORD

The Cotton Valley ostracodes exhibit varying stages of preservation, but they are generally less well preserved than those from the younger rocks of the region. They are mostly very small, and the shells are commonly filled with clay or pyrite, making observation of internal features difficult or impossible. Separated valves are not common.

Most of the ostracode genera found in the Cotton Valley appear to be new, but species of *Cytherella*, *Paracypris*, and *Cythereis* are present. Important sections of the faunule have complex hinge structures and muscle scar patterns similar to those found in certain Mesozoic and Cenozoic genera.

WELLS FROM WHICH COLLECTIONS WERE OBTAINED

1. Morgan, Smith no. 2, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana. Collections of ostracodes from this well were supplied by M. C. Israelsky. The top of the Schuler formation lies at 4730 feet. All of the species here described are from the Dorcheat member of the Schuler formation

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EXPLANATION OF PLATE 21

All figures approximately ×55

FIGS. *1, 2, 5—Hutsonia calahani* Swain, n. sp. *1a–b*, Left valve and ventral view of holotype, right valve imperfectly preserved slightly distorted; Phillips, Kendrick no. 1, 5620–40 feet. *2a–b*, Left valve and ventral view; Frankel, Muslow no. 1, 4580–90 feet. *5*, Left valve of specimen on which surface ornamentation is only partially preserved; Phillips, Kendrick no. 1, 5650–60 feet. (p. 126)

3, 4—Hutsonia israelskyi Swain, n. sp. *3a–b*, Right valve and dorsal view of a female (?), partly broken posteriorly; Phillips, Kendrick no. 1, 5620–40 feet. *4a–b*, Left valve and dorsal view of holotype, believed to represent a male example; Morgan, Smith no. 2, 5446–58 feet. (p. 126)

6a–b—Hutsonia imlayi Swain, n. sp., left valve and dorsal view of holotype; Phillips, Kendrick no. 1, 5620–40 feet. (p. 127)

7a–b—Hutsonia truncata Swain, n. sp., left valve and dorsal view of holotype; Morgan, Smith no. 2, 5446–58 feet. (p. 127)

8—Hutsonia parva Swain, n. sp., view of holotype, a separated left valve, slightly broken at posterior end; Union, Meadows no. A-1, 7875–80 feet. (p. 128)

9a–b—Hutsonia rugosa Swain, n. sp., left valve and dorsal view of holotype; Morgan, Smith no. 2, 5291–5311 feet. (p. 129)

2. Phillips Pet. Co., Kendrick no. 1, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana. Collections of ostracodes were obtained by the writer from well cuttings. Top of Schuler formation 4950 feet. All species here described are from Dorcheat member.

3. Humble O. & R. Co., Bliss and Weatherby no. 30, Sec. 15, T. 19 N., R. 11 W., Bossier Parish, Louisiana. Collections of ostracodes supplied by E. B. Hutson. All species listed are from the Dorcheat member of the Schuler, as determined by inference. The top of the Cotton Valley group is not accurately known.

4. Frankel Bros., Muslow no. 1, Sec. 30, T. 21 N., R. 7 W., Claiborne Parish, Louisiana. Collections of ostracodes obtained by the writer from well cuttings. The species listed is from the Dorcheat member of the Schuler.

5. Union Prod. Co., Meadows no. A-1, Sec. 18, T. 21 N., R. 4 W., Claiborne Parish, Louisiana. Collections obtained by the writer from well cuttings. Top of Schuler formation 7320 feet. The species listed is from the Dorcheat member.

6. Union Prod. Co., McDonald no. A-1, Sec. 13, T. 21 N., R. 5 W., Claiborne Parish, Louisiana. Collections obtained by the writer from well cuttings. Top of Cotton Valley group (Schuler formation) 7490 feet. A specimen of *Hutsonia vulgaris*, n. sp. var. *elongata*, n. var. was obtained at a depth of 10,555–60 feet, which is 3065 feet below top of Cotton Valley and lies within the Bossier formation. It is believed that this represents a caving sample, inasmuch as it

DISTRIBUTION OF SPECIES OF *Hutsonia*

Symbol (c) indicates specimens obtained from core samples, symbol (ct) indicates specimens obtained from rotary well cuttings.

Species	Name of well: Morgan-Smith No. 2 Bossier Psh., La.	Phillips-Kendrick No. 1 Bossier Psh., La.	Humble-B. & W. No. 30 Bossier Psh., La.	Frankel-Muslow No. 1 Claiborne Psh., La.	Union-Meadows No. A-1 Claiborne Psh., La.	Union-McDonald No. A-1 Claiborne Psh., La.
Hutsonia vulgaris	4955–73 c 5045–63 c 5063–81 c 5200 c 5277–93 c	5340–50 ct 5620–40 ct	5260–61 c			
Hutsonia vulgaris elongata	5045–63 c 5063–81 c 5200 c	5440–50 ct				10,555–60 ct
Hutsonia calahani	4927–55 c 4955–73 c 4973–91 c 5277–93 c	5620–40 ct 5650–60 ct		4580–90 ct		
Hutsonia israelskyi	5446–58 c	5650–60 ct				
Hutsonia truncata	5446–58 c					
Hutsonia imlayi	5200 c	5620–40 ct				
Hutsonia parva					7875–80 ct	
Hutsonia rugosa	5277–91 c 5291–5311 c					

lies far below the stratigraphic level of the other known occurrences of the new variety. The specimen has been recorded because it is the only representative of the genus found in the well.

RANGE OF THE SPECIES

With but the one questionable exception noted above, all of the species here described were collected from the Dorcheat member of the Schuler formation, but more wells must be studied before the precise range of each species can be determined. On the basis of present limited knowledge it appears that *Hutsonia vulgaris*, n. sp. and *H. calahani*, n. sp., at least, may be restricted to the Dorcheat member.

ACKNOWLEDGEMENTS

Sincere appreciation is expressed to M. C. Israelsky, Houston, Texas and E. B. Hutson, Shreveport, Louisiana who kindly loaned collections of Cotton Valley ostracodes; F. E. Lozo, Jr., aided in making arrangements for the loan of the Israelsky collection, and T. H. Philpott made similar arrangements in the case of the Hutson collection. Joseph Purzer kindly supplied certain well information. Particular thanks are extended to F. M. Swartz who aided in the photography and read the manuscript critically. John B. Reeside, Jr., and Carle H. Dane helpfully examined the manuscript and made a number of editorial changes.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille
Family CYTHERIDAE Baird, 1850
Genus HUTSONIA Swain, n. gen.

Jonesina sp., L. W. Calahan, 1939, Shreveport Geol. Soc. Guidebook Fourteenth Annual Field Trip, p. 56.

Shell sub-pyriform in side view; dorsal margin nearly straight to slightly sinuate; ventral margin moderately convex rising posteriorly to the narrowly rounded, in some species bluntly pointed, posterior end; anterior end broadly and uniformly rounded, greatest height near anterior end; greatest length nearly median, slightly oblique; greatest thickness just posterior to middle of valves. Left valve slightly larger than right, overlapping it at least along the free margins; ventrally in most species, left valve projects below right, as seen in end view.

Surface of anterior one-fifth of valves forms a broad, marginal swelling, which in some species continues ventrally and then posteriorly nearly or actually to valve end but in other species passes into shell surface about at or somewhat dorsal to the antero-ventral marginal bend. A rounded, swollen area lies just posterior to and mostly above valve middle; in some species this swelling projects above dorsal margin as seen in side view, but in other species it is less pronounced. Surface of valves lying between anterior flank of dorso-median swelling and post-dorsal flank of anterior marginal swelling is typically bisulcate, but at least one species (*H. truncata*, n. sp.) is unisulcate. In the bisulcate species, the sulci are separated either by a dorso-ventrally elongated lobe or by a rounded node. Of the two sulci, the anterior one extends farther ventrally and near its dorsal termination it is characteristically deepened to form a pit-like depression.

Shell surface reticulate, smooth or with coarse ridges; reticulate species have longitudinal ridges on ventral parts of marginal swelling.

Hinge structure of left valve, as seen in one separated valve of *H. vulgaris*, n. sp. consists of terminal, elongate, taxodont dental areas connected by a narrow ridge; hinge structure of right valve not observed, but is presumably the antithesis of the left.

Muscle scar of the genotype, as observed by reflected light under oil, consists of a vertical row of four subcircular spots, lying slightly in front of valve middle, and one sub-crescentic spot lying anterior to the main group. A number of other accessory spots may be present, but could not be observed clearly. Scar seen in only this one specimen.

Other details of internal structure could not be observed, either by reflected or by transmitted light, under oil, owing to conditions of preservation, but in a number of specimens which exhibit translucent edges, marginal pore canals appear to be lacking.

Dimorphism is believed to occur in the genus. In *H. vulgaris*, n. sp. and its variety *elongata* there is distinct variation in the relative obesity of the postero-ventral

portions; one group, presumed to represent the males, is relatively emaciated in this area, and the other group, thought to represent the females, is relatively tumid there.

Relationships.—Hutsonia is here placed in the family Cytheridae because it has a partly denticulate hinge and a muscle-scar pattern consisting of a vertical row of pits and a more anterior pit, characters possessed by many genera now included in that family. The family relationships of a large number of Mesozoic and Cenozoic ostracode genera, based on hard parts, have not been clarified, so that the present assignment of *Hutsonia* to the Cytheridae is tentative.

The new genus is close to the late Jurassic forms identified as *Metacypris* Brady and Robertson, which occur in the Purbeck of England (12), the Bahia of Brazil (13) and the Morrison formation of South Dakota (14, 15, 16). The late Jurassic species of "*Metacypris*" are like *Hutsonia* in that most of them bear two antero-median dorsal sulci, have a pitted or roughly reticulate surface and a ribbed ventrum. *Hutsonia* has a much narrower, more pointed posterior end as seen in side view. Its hinge is denticulate at both ends, whereas in the Morrison species of "*Metacypris*" the hinge is reported to bear a posterior tooth, and to have a furrow and flange in its posterior half; the anterior half of the hinge is described only as "distinct" (15, p. 624).

Roth (14) originally placed the Morrison representatives in *Jonesina*, subsequent to which Harper and Sutton (15) assigned them to *Metacypris*. As compared to *Hutsonia*, although it is a bisulcate form, the hinge of *Jonesina* is described as obscurely cardine, and its posterior extremity is much more broadly rounded.

The terminal, elongate, taxodont hinge areas of *Hutsonia* are reminiscent of similar features found in such genera as *Cytheropteron* Sars, *Orthonotocythere* Alexander, and *Xestoleberis* Sars. In *Hutsonia*, however, there does not appear to be crenulation of the hinge-surface between the terminal dental areas.

Genotype, *Hutsonia vulgaris*, n. sp. Genus named in honor of E. B. Hutson, Shreveport, Louisiana, for many years a student of Gulf Coast paleontology.

HUTSONIA VULGARIS Swain, n. sp.
Plate 20, figures 1–6; text fig. 1

Shell sub-pyriform in side view; dorsal margin somewhat sinuate; ventral margin moderately convex, rising strongly backward into the narrowly rounded posterior

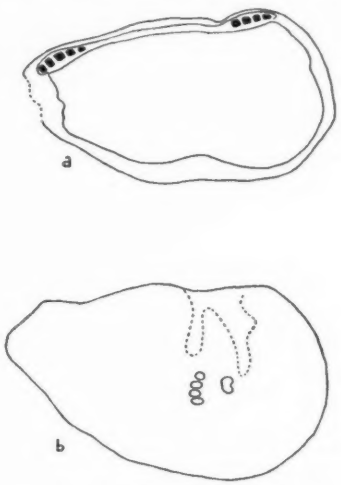

FIG. 1—*a*, Separated left valve of a specimen of *Hutsonia vulgaris*, n. sp., showing hinge structure; valve filled with matrix; Humble O. & R. Co., Bliss and Weatherby no. 30, Bossier Parish, Louisiana, core 5260–61 feet. *b*, Holotype *H. vulgaris* by reflected light under oil, showing muscle-scar pattern.

end; anterior end broadly and uniformly rounded; greatest height near anterior end; greatest length oblique, nearly median; greatest thickness just posterior to middle of valves. Left valve slightly larger than right, overlapping it inconspicuously along free margins; ventrally, left valve projects slightly below right as seen in end view.

Surface of anterior one-fifth of valves forms a broad marginal swelling which continues ventrally and posteriorly along ventral surface to about one-fourth distance from posterior end, where it dies out. A rounded swollen area lies just behind and mostly above valve middle; this projects slightly above dorsal margin as seen in side view. Surface lying between anterior flank of dorso-median swelling and post-dorsal part of anterior marginal swelling bisulcate;

anterior sulcus longer and deeper than the other, and near its dorsal termination it deepens to form a pit-like depression; sulci separated by a dorso-ventrally elongated lobe which acuminates dorsally just below margin, and ventrally, passes into shell surface just below middle of valves; a transverse elevation lies a short distance below dorsal termination of lobe, and in most specimens it is extended slightly to anterior as a short spur, with subjacent notch. A corresponding, stronger spur projects backward from the posterior slope of the anterior marginal swelling. Posterior slope of dorso-median swelling passes gradually backward nearly to end of valves where it descends abruptly into the narrow, lip-like posterior valve termination.

Finer ornamental details as follows: anterior portion of marginal swelling faintly reticulate, having longitudinal elements of reticulum stronger; ventral portion of marginal swelling bearing longitudinal ridges, the pattern becoming faintly reticulate dorsally; dorsal one-half of antero-median lobe and its bounding sulci, smooth; remainder of valve surface roughly reticulate, with posterior one-fourth only weakly ornamented.

Muscle scar of holotype, as seen by reflected light under oil, lies just anterior to valve middle and ventral to antero-median lobe; it consists of a vertical row of four, small, sub-rounded spots together with a single, more anterior, sub-crescentic spot; accessory spots may be present but could not be observed clearly.

Hinge of a separated left valve belonging to the species, consists of terminal, elongate, taxodont dental areas connected by a narrow ridge; hinge of right valve not observed in material at hand, but is presumably the antithesis of that of left. Other details of internal structure not observed, owing to conditions of preservation.

Specimens at hand, fall into two groups with respect to the height of the posterior portions of the valves, but are otherwise similar; thus in one group, ventral margin converges rather uniformly with dorsal margin, except for offset along ventral margin made by posterior termination of marginal swelling; in other group, ventral margin is sub-parallel to dorsal margin in anterior two-thirds of shell, then rises rapidly toward posterior end. This latter group also exhibits a somewhat thicker posterior portion as seen in edge view, and as a result, shells of group apparently enclose a greater volume of space than do those of other group. Specimens representing both elements of this association have been collected from a single well-level. Inasmuch as the varying obesity of members of the species lies in a postero-ventral position, sexual dimorphism is suggested. The relatively tumid specimens are thought to represent females, and the less tumid ones males.

Dimensions.—Length of holotype a complete example, 0.83 mm., height 0.42 mm., thickness 0.31 mm.

Relationships.—*H. vulgaris* differs from its variety *elongata*, n. var., in being relatively shorter and higher. Except in size. *H. parva*, n. sp., is very close in shape and lobation, but in *vulgaris* the ventral marginal swelling is less pronounced, and the surface details of ornamentation are better developed.

Occurrence.—The holotype, a complete male example, obtained from well cutting sample, Phillips Pet. Co., Kendrick no. 1, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana at 5620–40 feet, 670 feet below top of Schuler formation in Dorcheat member. Other known occurrences listed in table 1; all lie within the Dorcheat member.

HUTSONIA VULGARIS ELONGATA
Swain, n. var.
Plate 20, figures 7–10

Similar in surface ornamentation to *H. vulgaris;* differs in being relatively more elongate, having ventral portion of marginal swelling somewhat less well defined in examples presumed to be male dimorphs, and in having no definition of the ventral marginal swelling in a specimen presumed to be a female dimorph.

Dimensions.—Length of holotype 0.84 mm., height 0.43 mm., thickness 0.38 mm.

Occurrence.—The holotype, a complete female example, from core sample, Humble O. & R. Co., Bliss & Weatherby no. 30, Sec. 15, T. 19 N., R. 11 W., Bossier Parish, Louisiana, at 5260–61 feet, believed to represent horizon of Dorcheat member of

Schuler formation. Other occurrences listed in table 1. With one exception all are from Dorcheat member. This exception, a specimen from Union Prod. Co., McDonald no. A-1 well, Sec. 13, T. 21 N., R. 5 W., Claiborne Parish, Louisiana, obtained from well-cutting sample at 10,555–60 feet, at horizon of middle part of Bossier formation. The specimen may have caved from higher levels and is of questionable stratigraphic value.

HUTSONIA CALAHANI Swain, n. sp.
Plate 21, figures 1, 2, 5

Shell sub-pyriform in side view; dorsal margin slightly sinuate; ventral margin moderately convex, converging posteriorly toward dorsum; anterior end broadly and uniformly rounded; posterior end narrowly rounded; greatest height near anterior end; greatest length slightly oblique, about median; greatest thickness just back of middle. Left valve larger than right, overlapping it at least along free margins; ventrally, left valve projects below right along its middle portion. As seen in ventral view, ventral valve edges are somewhat impressed along middle two-thirds.

Surface of anterior one-fifth of valves forms a broad marginal swelling, which continues around antero-ventral marginal bend and along ventral surface to about one-fourth distance from posterior end where it dies out; behind antero-ventral marginal bend, however, the marginal swelling is narrow and less elevated than dorsal to this bend. A rounded swollen area lies just behind and mostly above valve middle, projecting slightly above dorsal margin as seen in side view. Surface lying between anterior flank of the rounded dorso-median swelling and posterior flank of the antero-marginal swelling is weakly to inconspicuously bisulcate; anterior sulcus more extended ventrally than the other, and near its dorsal termination it becomes deepened to form a pit-like depression. Between the two sulci and about one-fourth distance from dorsum, lies a small rounded node. A short spur from posterior flank of anterior marginal swelling projects toward the node.

Details of finer surface ornamentation as follows: surface of anterior portion of marginal swelling imperfectly reticulate, with the longitudinal elements of the reticulum more prominent; ventral portion of marginal swelling bears longitudinal ridges; at posterior end of marginal swelling in holotype, ridges bend dorsally for a short distance. Surface of dorso-median swelling bears irregularly disposed ridges and grooves; remainder of surface with few scattered nodes and short ridges, but mostly smooth.

Details of muscle scar, hingement and other internal features not observed owing to conditions of preservation.

Evidence of dimorphism in the species not clearly observed in specimens at hand.

Dimensions.—Length of holotype 0.56 mm., height 0.34 mm., thickness 0.30 mm.

Relationships.—*H. calahani* differs from *H. vulgaris*, n. sp., in that it bears a subdorsal node instead of a lobe. It is close to *H. israelskyi*, n. sp., but the ventro-marginal swelling does not extend to the posterior end, as in that species. Species named in honor of L. W. Calahan.

Occurrence.—Holotype, a complete example, from well-cutting sample, Phillips Pet. Co., Kenderick no. 1, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana, 5620–40 feet, 670 feet below top of Cotton Valley group, in Dorcheat member of Schuler formation. Other occurrences listed in table 1, all from Dorcheat member.

HUTSONIA ISRAELSKYI Swain, n. sp.
Plate 21, figures 3, 4

Shell sub-pyriform acuminate in side view; dorsal margin slightly sinuate; ventral margin moderately convex and somewhat sinuate, rising posteriorly to the pointed posterior end; anterior end broadly and nearly uniformly rounded; greatest height near anterior end; greatest length oblique, about median; greatest thickness just behind middle of valves. Valves nearly equal in size, the left slightly larger.

A broad marginal swelling occupies slightly less than one-fifth of anterior end of valves; this continues along ventrum to posterior end, but the pointed posterior valve-termination is somewhat compressed. A well defined and pronounced rounded swelling lies just behind and mostly above middle of valves, and projects slightly above dorsum as seen in side view. Surface lying between the anterior flank of this

dorso-median rounded swelling and posterior flank of antero-marginal swelling inconspicuously bisulcate; anterior sulcus deepened and somewhat expanded near its dorsal termination to form a pit-like depression. A small node lies between the two weakly-defined sulci, about one-fourth distance from dorsum. A prominent blunt spur from posterior flank of antero-marginal swelling projects toward node.

Shallow pitting, forming an ill-defined reticulate pattern is present on most of surface, except ventral portion of marginal swelling which bears ridges parallel to margin; sub-dorsal node and surrounding area, smooth. Longitudinal ridges weakly developed on ventro-marginal swelling.

Details of muscle scar, hingement and other internal features have not been observed owing to conditions of preservation; as seen by transmitted light, the partly translucent edges of the holotype appear to lack marginal pore canals.

Sexual dimorphism in the species is questionably evidenced by one imperfectly preserved specimen which is relatively high posteriorly as seen in side view, and is relatively thick posteriorly as seen in edge view.

Dimensions.—Length of holotype 0.65 mm., height 0.38 mm., thickness 0.30 mm.

Relationships.—*H. israelskyi* is close to *H. calahani*, n. sp., but differs in having the marginal swelling extended to the posterior end, and in having the anterior part of the marginal swelling more elevated. *H. truncata*, n. sp. is less pointed posteriorly, and has a very blunt anterior end as seen in side view, but is otherwise similar to *H. israelskyi*. Species named in honor of M. C. Israelsky.

Occurrence.—Holotype, a complete example, believed to be a male, from core sample, Morgan, Smith no. 2, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana, 5446–58 feet, 716 feet below top of Cotton Valley group in Dorcheat member of Schuler formation.

HUTSONIA IMLAYI Swain, n. sp.
Plate 21, figure 6

Shell sub-pyriform in side view; dorsal margin nearly straight; ventral margin moderately convex, rising posteriorly to the narrowly rounded posterior end; anterior end broadly and uniformly rounded; greatest height near anterior end; greatest length lying obliquely above middle of valve; greatest thickness median. Valves nearly equal in size, left slightly larger than right.

Surface of anterior one-fifth of valves forms a low arcuate swelling which merges into general valve surface about one-fourth distance from ventral margin. A broad, ill-defined swelling lies behind and mostly above valve middle. Surface anterior to this swelling and posterior to antero-marginal swelling bisulcate; anterior sulcus the longer of the two and is somewhat expanded and deepened near its anterior termination. A dorsally acuminate lobe, terminating a little below dorsal margin, separates the two sulci. Anterior flank of lobe bears a short spur and subjacent notch about one-third distance from dorsal margin; a corresponding spur, directed posteriorly, lies on the posterior flank of the marginal swelling. Surface otherwise smooth. Internal features unknown.

Dimensions.—Length of holotype 0.65 mm., height 0.38 mm., thickness 0.30 mm.

Relationships.—*H. imlayi* is close to *H. vulgaris*, n. sp. in its general outline and possession of a dorsally acuminate lobe, but differs in its lack of surface reticulation and pitting, and in the lesser development of a marginal rimlike swelling. *H. parva*, n. sp. has a pronounced ventro-marginal swelling and bears fine surface ornamentation, but in the nature of its sulcation it is close to the species under discussion. Species named in honor of R. W. Imlay.

Occurrence.—Holotype, a complete example, from well-cutting sample, Phillips Pet. Co., Kendrick no. 1, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana, 5620–40 feet, 670 feet below top of Cotton Valley group in Dorcheat member of Schuler formation. Other well preserved examples from Dorcheat member obtained from core, Morgan, Smith no. 2 well, Bossier Parish, Louisiana at 5200 feet. In this collection are examples which are somewhat more acuminate posteriorly than the holotype.

HUTSONIA TRUNCATA Swain, n. sp.
Plate 21, figure 7

Shell sub-pyriform-truncate in side view; dorsal margin sinuate; ventral margin moderately convex, rising rather abruptly

to the narrowly rounded posterior end, from a point just behind valve middle; anterior end truncate, bending rather sharply into dorsum and ventrum; greatest height just behind anterior end; greatest length about one-third distance from dorsum, and about parallel to dorsal and ventral margins; greatest thickness about median. Left valve slightly larger than right, overlapping it along the free margins; ventrally, left valve projects below right as seen in end view.

Surface of anterior one-fifth of valves forms a well defined marginal swelling which continues along ventrum to posterior end where it broadens somewhat, but does not include posterior compressed valve-termination. Inner flank of antero-marginal swelling notched just below its dorsal termination; immediately ventrad of the notch a prominent spur projects backward from the inner flank of the marginal swelling. A rounded, pronounced swelling lies on surface of valves in a dorso-median position; it projects slightly above dorsal margin as seen in side view, and possesses a short, anteriorly directed spur on its anterior flank, about one-third distance from dorsal margin. Surface lying between the anterior flank of the dorso-median swelling and the posterior flank of the antero-marginal swelling forms a single, broad sulcus; a pit-like depression lies in the sulcus near its dorsal termination.

Surface of dorso-median swelling coarsely pitted; ventral portion of marginal swelling bears coarse ridges parallel to margin; surface otherwise smooth or with a few scattered pits.

Muscle scar, hingement and other details of inner structure not known; when examined by transmitted light under oil, the holotype appeared to lack marginal pore canals.

Dimensions.—Length of holotype 0.50 mm., height 0.35 mm., thickness 0.30 mm.

Relationships.—*H. truncata* somewhat resembles *H. israelskyi*, n. sp. in that both have the ventral marginal swelling extended to the posterior end, but *H. truncata* is more blunt posteriorly, has a more truncate anterior end, is unisulcate, and lacks an antero-median node.

Occurrence.—Holotype, a complete example, from core sample Morgan, Smith no. 2 well, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana, 5446–58 feet, 716 feet below top of Cotton Valley group in Dorcheat member of Schuler formation.

HUTSONIA PARVA Swain, n. sp.
Plate 21, figure 8

Description of holotype, a delicate left valve, broken posteriorly and affixed to a shale fragment, is as follows: valve subpyriform in side view; dorsal margin nearly straight; ventral margin moderately convex, converging posteriorly with dorsum; anterior end broadly and uniformly rounded; greatest height about one-third distance from anterior end; greatest length dorso-median.

Surface of anterior one-fifth of valves forming a marginal swelling, which acuminates dorsally near the margin; it continues along ventral surface; along its ventral course, swelling produced downward to overhang ventral edge. A low, rounded swelling lies just behind and mostly above valve middle. Between the two swollen areas in dorsal two-thirds of valve, lies a dorsally-acuminating lobe, bounded on either side by narrow sulci, of which the anterior one is the deeper and more extended ventrally; about one-half distance from dorsal termination of lobe, its anterior flank is marked by a short spur and subjacent notch. Surface of valve behind dorso-median swelling slopes gradually toward posterior end. Dorsal one-half of antero-median lobe, and bounding sulci, smooth; remainder of valve weakly pitted; some weak longitudinal ridges lie ventral to antero-median lobe.

Hingement, muscle scar, and other features of internal structure not known.

Dimensions.—Length of holotype 0.57 mm., height 0.38 mm.

Relationships.—In the nature of its sulcation *H. parva* is close to *H. imlayi*, n. sp., but unlike that species it possesses a pronounced ventro-marginal swelling and a pitted surface. As compared to *H. vulgaris*, n. sp., the species under discussion has similar sulcation, but the ventro-marginal swelling is more extended ventrally and the surface ornamentation is weaker. At one stage it was considered possible that the specimen of *H. parva* might represent an

immature molt of *H. vulgaris*, but it is now felt that the difference in ventral overhang of the marginal swelling is sufficient basis for considering this a distinct species.

Occurrence.—Holotype, a separated left valve, from well-cutting sample, Union Prod. Co., Meadows no. A-1, Sec. 18, T. 21 N., R. 4 W., Claiborne Parish, Louisiana, 7875–89 feet, 555 feet below top of Cotton Valley group in Dorcheat member of Schuler formation.

HUTSONIA RUGOSA Swain, n. sp.
Plate 21, figure 9

Shell sub-ovate in side view; dorsal margin nearly straight; ventral margin nearly straight along anterior two-thirds, rising behind to the narrowly rounded posterior end; anterior end broadly rounded, extended below; greatest height near anterior end; greatest length oblique, about median; greatest thickness about one-third distance from posterior end. Valves nearly equal, the left slightly larger.

Surface of anterior one-fifth of valves forms an elevated arcuate marginal area; just behind antero-ventral marginal bend it narrows to a ridgelike marginal rim and near valve middle it passes into general surface. Surface of posterior half of valves forms a broad elevation. Surface lying between posterior elevation and antero-marginal elevation roughly bisulcate, the posterior sulcus being the longer of the two; sulci separated by a dorso-ventrally directed ridge which bifurcates toward ventrum near valve-middle, one branch extending toward antero-ventral marginal bend to meet the marginal elevation, the other branch extending ventrally to meet the ventral marginal rim. Surface of elevations strongly sculptured with coarse, irregularly disposed, discontinuous ridges.

Hingement, muscle scar, and other details of internal structure not observed.

Dimensions.—Length of holotype 0.70 mm., height, 0.35 mm., thickness 0.30 mm.

Relationships.—In general shape and disposition of elevations and sulci, this species agrees with features outlined for other members of the genus. Its rugose surface ornamentation separates it from the other described species of *Hutsonia*.

Occurrence.—Holotype, a complete example, from core sample Morgan, Smith no. 2, Sec. 22, T. 19 N., R. 11 W., Bossier Parish, Louisiana, 5291–5311 feet, 561 feet below top of Cotton Valley group in Dorcheat member of Schuler formation.

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FORAMINIFERA FROM THE TYPE PEPPER SHALE OF TEXAS

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ABSTRACT—Twelve new species of smaller arenaceous Foraminifera are described from the type locality of the Pepper shale (Upper Cretaceous) of Texas, representing eleven genera and six families. Evidence in support of the shallow, brackish water origin and early Woodbine age of the formation is discussed, although exact correlation on the evidence of the Foraminifera is not possible as yet, due to the absence of any previously described species.

HISTORICAL SUMMARY

DEFINITION.—The Upper Cretaceous Pepper formation was defined by Adkins (1932, p. 417) as follows: "The basal, non-calcareous, blue-purplish clay shale which extends southward from the Woodbine outcrop proper in McLennan County and underlies the *Acanthoceras* flags of the Eagle Ford is a distinct stratigraphic unit. It is separated from the underlying Grayson (Del Rio) by an unconformity, represented by a pebble conglomerate. Its top is marked by a sharp break in the character of sedimentation, the overlying Tarrant formation being an arenaceous flaggy limestone containing much fish debris, phosphatic bodies and fossil wood, and showing many evidences of shallow-water deposition."

Type Section.—The following stratigraphic section, measured by Adkins and Arick (1930, pp. 53–54), is that of the type locality: an exposure on a small branch of Pepper Creek, just south of the Belton-Temple highway, Bell County, Texas, and 1.6 miles east of the easternmost of two underpasses of the highway under the Santa Fe Railway.

SECTION ON BRANCH OF PEPPER CREEK

Zone		Feet
	Austin Chalk	
	Typical Austin chalky limestone exposed up creek	5+
	Eagleford	
I	Black shale and thin lime flags with bentonite seams in abandoned interurban cut	30
H	Black lustrous shale, about	20
G	Limestone flag member (*Acanthoceras* zone)	5
	Pepper formation	
F	Black lustrous shale, purplish when dry; fossils; about	49
E	Black lustrous gypsiferous shale, abundant euhedral selenite crystals; some fossils; 177 mm.	0.6
D	Reworked zone: sandy carbonaceous, gypsiferous clay with quartz, phosphate and other pebbles, fish remains, lignitized wood, rolled Del Rio fossils; 134 mm., of which basal 45 mm. is especially carbonaceous and rich in phosphatic pebbles; contains *Gryphea mucronata*, *Exogyra arietina* (?), phosphatized fossils	0.45
	Del Rio	
C	Typical Del Rio clay: *Pecten*, other fossils, 448 mm.	1.5
B	Del Rio soft clayey limestone, 97 mm.	0.3
A	Typical Del Rio clay; exposed	0.7
	Typical Del Rio clay, exposed downstream, about	25

Correlation.—Adkins and Arick (1930, p. 59) included the then unnamed Pepper as a member of the Eagleford, but stated that some writers considered it to be of Woodbine age on the basis of the lithology and stratigraphic position. They further stated that these shales contain fossils unlike any Woodbine species so far described from Texas and that the exact determination of age must await a closer study of the fossils. Adkins (1932, p. 418), in defining the Pepper formation, placed the discussion under the Woodbine group with reservations, saying, "It may be a part of the Woodbine, a question still open for debate."

Stephenson (1927) considered these clays, mapped and considered as Eagleford by some, to be the southern extension of the Woodbine, which was believed to pinch out and disappear in Hill County. No faunal evidence in support of these conclusions is known to the present writer.

Scott (1931) stated that the base of the Woodbine throughout Hill, Johnson, Tar-

rant, Denton, Cooke and Grayson counties is a dark laminated clay ranging in thickness from 5 to 25 feet. According to Scott the upper Grayson grades imperceptibly upward into these clays and he saw no evidence of unconformity between them. In addition these dark blue clays have a fauna of Washita affinities. Helen Tappan Loeblich and the writer have collected and studied numerous samples of these lower Woodbine shales from north Texas but we have failed to notice any that have a microfauna of Washita affinities. The contact is a difficult one to study as the overlying sediments are soft and the contact is usually obscured by Woodbine wash. Few contacts are as excellently exposed as that at the type Pepper locality.

Bailey, Evans and Adkins (1945, p. 183) stated that "in view of the overwhelming evidence for a widespread unconformity at the base of the Woodbine, the presence of diagnostic Upper Cretaceous ammonites, gastropods, and pelecypods in the upper Woodbine . . . and of a few fossils known from the lower Woodbine but unreported from the Comanche, the logical boundary between the Upper and Lower Cretaceous seems to be the base of the Woodbine 'formation'." They described a subsurface post-Buda Washita formation, the Maness shale, which underlies the Woodbine in Eastern Texas, but does not crop out, as far as known. They stated (p. 176) that "the possibility that Maness is represented in the basal Woodbine at the surface in northeast Texas is neither proved nor disproved paleontologically; at any rate, the Maness fauna has so far been found nowhere at the outcrop." While the Foraminifera have not yet been described from the Maness shale, the fauna is described as Washita in appearance and therefore is unlike that of the Pepper formation, which immediately overlies the Buda at the outcrop farther to the south.

METHOD OF STUDY

Channel samples were collected in the field by the writer, were washed in the laboratory and boiled in water to which baking soda had been added, then washed with a spray over a 200 mesh screen. After drying, the samples were sieved through screens of the following mesh sizes: 10, 20, 40, 60, 100 and 140. Material remaining on the 10, 20 and 40 mesh screens was sorted with a magnification of 20 diameters, that on the 60, 100 and 140 mesh screens with a ×40 magnification and the concentrate remaining on the pan was examined at ×80 magnification. Due to the extremely small size of the species in the present fauna, the finer concentrates were the most fossiliferous and many of the species would have escaped notice without the use of the higher magnifications in sorting the samples.

Illustrations are shaded camera lucida drawings, originally made at twice the present magnification and reduced one-half in reproduction.

All types and figured specimens are deposited at the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts. Paratypes are deposited in the Cushman Collection and in the writer's collection.

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SAMPLES

The following samples from the type locality were studied by the writer:

Locality HTL-167
Pepper Clay (Type Locality)
Collected August 12, 1941

Sample	Description
665.	5½ feet, light purple-gray, thin-bedded, yellow-stained shale. Residue of limonitic shale with a few clay ironstones. Uppermost sample collected, grass-covered above.

664. 5½ feet, light purple-gray, thin-bedded, yellow-stained shale with impressions of pelecypods. Residue of very abundant orange to yellow limonitic clay with some gray fissile shale. Just below sample 665.
663. 2¾ feet, thin-bedded, blue-gray, yellow-stained clay with limonitic pelecypod casts and selenite crystals. Residue with siderite clay (ironstone concretions) abundant, glauconitic, micaceous, fine-grained sandstone lenses, shale. Just below sample 664.
662. 2¾ feet, thin-bedded, purple-gray, yellow-stained clay, gives a petroliferous odor when boiling. Residue: yellow and yellow-brown shale, pyrite aggregates, little gray shale and little clay ironstone. Just below sample 663.
661. Three inches of dark gray clay on the surface. Residue essentially a calcareous sand composed of reworked Grayson (Del Rio) fossils, little quartz with glauconite and black pebbles. This sample contains many reworked Foraminifera, but none of the arenaceous species indigenous to this formation. Base of the Pepper formation, Grayson (Del Rio) clay immediately beneath.

Sample 661 is from zone D, number 662 From E and F, and 663 to 665 are also from the lower part of zone F of Adkins and Arick. Material above 665 was not well exposed, largely obscured by wash and grass-covered.

PALEONTOLOGY

Adkins (1932) recorded the following fauna from the type Pepper formation:

Neocardioceras (?)
Scaphites
Euhystrichoceras (?)
Plicatula sp. aff. *arenaria* Meek
Tapes sp. aff. *cyprimeriformis* Stanton
Avicula sp. aff. *gastrodes* Meek
Anchura sp.

Plummer (in Adkins, 1932, pp. 419–420) recorded the following Foraminifera:

Ammobaculites (2 species)
Ammodiscus
Reophax

There are numerous reworked calcareous Foraminifera in the Pepper samples studied. The specimens are frequently broken and eroded and can easily be distinguished from the indigenous Pepper species. The reworked forms are probably all from the underlying Grayson (Del Rio). The following reworked fossils are recorded by the writer:

Sample 661 (Pebble layer at the base)
Textularia rioensis Carsey
Lenticulina gaultina (Berthelin)
Nodosaria obscura Reuss
Vaginulina cf. *linearis* (Reuss)
Vaginulina raristriata (Chapman)
Pyrulina cylindroides (Roemer)
Ramulina cf. *globulifera* Brady
Gümbelina washitensis Tappan
Gümbelitria harrisi Tappan
Spirillina minima Schacko
Turrispirillina subconica Tappan
Patellina subcretacea Cushman and Alexander
Valvulineria asterigerinoides Plummer
Valvulineria loetterlei (Tappan)
Globigerina graysonensis Tappan
Globigerina sp.
Anomalina plummerae Tappan
Gryphea mucronata Gabb
Echinoid fragments
Starfish fragments
Ophiuroid ossicles
Holothuroid spicules
Numerous ostracods
Fish, bone fragments and teeth

Sample 662
Lenticulina gaultina (Berthelin)
Valvulineria loetterlei (Tappan)

Sample 663
None

Sample 664
Ramulina sp.
Valvulineria loetterlei (Tappan)
Anomalina plummerae Tappan
Cythereis sp.

Sample 665
Spiroplectammina alexanderi Lalicker
Textularia rioensis Carsey
Vaginulina debilis (Berthelin)
Valvulineria loetterlei (Tappan)
Globigerina sp.
Anomalina plummerae Tappan
Ophiuroid ossicles
Cythereis (?) sp.

CONCLUSIONS

Environment.—The writer believes these sediments were deposited in shallow waters of low salinity, because of the presence of abundant siderite and limonite concretions, the presence of large numbers of reworked calcareous forms, the absence of any indigenous calcareous Foraminifera in the type Pepper, the small size of the arenaceous species, the large amount of organic matter in some of the samples, and the limited megafauna, which consists only of mollusks and worms.

Correlation.—The present fauna consists entirely of new species, and hence cannot

settle the question of the correlation of the Pepper formation, but perhaps can be used for comparison when the microfauna of the Woodbine is better known.

The sediments that overlie the Buda and underlie the Eagle Ford at Austin, in Travis County, are in the same stratigraphic position as the Pepper, but are microfaunally unlike the type Pepper. The former has a normal marine fauna of calcareous Foraminifera, Ostracoda, microscopic crinoids, similar to those described by Peck from the Lower Cretaceous, and many other fragmentary fossils. They may be of the same age, however, with the apparent difference in fauna due to environment.

The only Woodbine foraminifera described from northern Texas are those of Tappan (1941), which are also entirely unlike the present species, as they are unusually large forms. This fauna consists of two species of *Flabellammina* and a large *Reophax*. In addition, Bailey, Evans and Adkins (1945, p. 184) state that "a few generalized types of arenaceous Foraminifera were found in outcrop samples . . . " of the dark gray to black shales of the Woodbine in North Texas. The species were not listed however. The writer has examined a number of samples of basal Woodbine from North Texas containing a fauna of tiny arenaceous species. Although these smaller lower Woodbine species of North Texas have not yet been thoroughly studied or described, they are similar in general appearance to the species in the Pepper shale, and the type Pepper fauna appears more closely related to that of the lower Woodbine of North Texas than to any other. However, until further study of the northern species is made, this appearance cannot be used for definite correlation, as it may be due to similar environment, rather than equivalent age.

SYSTEMATIC DESCRIPTIONS

Twelve new species of Foraminifera are here described from the Pepper shale, representing eleven genera and six families. The largest number of species belongs to the family Lituolidae, which is represented by four species; the Textulariidae is represented by three species, and the Ammodiscidae by two species. The Reophacidae, Verneuilinidae and Trochamminidae are each represented by a single species. All of the species are agglutinated and insoluble in acid.

Family REOPHACIDAE
Subfamily REOPHACINAE
Genus REOPHAX Montfort, 1808

REOPHAX PEPPERENSIS Loeblich, n. sp.
Plate 22, figures 1a–b

Test free, minute, elongate, consisting of uniserially arranged chambers; chambers numerous, rounded in section, length somewhat less than diameter, but of varying proportions; sutures straight, distinct, slightly depressed; wall finely arenaceous; insoluble in acid, composed of clear or brownish quartz grains, with small amount of cement, surface rough; aperture terminal, rounded, at the end of a very slight neck; color white to brown to gray.

Length varies from 0.129 mm. to 0.214 mm. Length of holotype 0.207 mm., greatest breadth 0.057 mm.

Types.—Holotype, Cushman Coll. No. 44096, from sample 663, at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44097 and Loeblich Coll. No. 1027.

Remarks.—Reophax pepperensis, n. sp. is similar to *R. arctica* Brady, but is smaller in size and rounded, rather than ovate, in cross section. It is also similar to *R. suevica* Franke but has more numerous chambers and is considerably smaller in size. This species was found only in sample 663, and is represented by 24 specimens.

Family AMMODISCIDAE
Subfamily AMMODISCINAE
Genus AMMODISCUS Reuss, 1861

AMMODISCUS PLANUS Loeblich, n. sp.
Plate 22, figures 2a–b

Test free, planispiral, discoidal, small, periphery rounded; tiny globular proloculum followed by a long undivided tubular second chamber which is ovate in section and enlarges gradually in size, so that the test is thinnest centrally; spiral suture between the coils distinct, depressed; wall thin, very finely arenaceous, with much cement, not soluble in acid, surface smoothly finished, with an almost hyaline appearance; aperture ovate, with breadth greater than height; color whitish.

Specimens vary in diameter from 0.129 mm. to 0.329 mm. Greatest diameter of holotype 0.286 mm., least diameter 0.25 mm., thickness 0.03 mm.

Types.—Holotype, Cushman Coll. No. 44098 from sample 665 at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44099 and Loeblich Coll. Nos. 1028 and 1029.

Remarks.—This species is similar to *Ammodiscus glabratus* Cushman and Jarvis, from the Cretaceous of Trinidad, but *A. planus*, n. sp., is smaller and much thinner. This species occurs in samples 662 to 665, inclusive, and is represented by 327 specimens.

Genus GLOMOSPIRA Rzehak, 1888
GLOMOSPIRA WATERSI Loeblich, n. sp.
Plate 22, figures 3a–b, 4; text figures 1a–c

Test free, small, irregularly discoidal, with tubular second chamber winding irregularly about the proloculum, generally planispiral, but in some cases spiral in plan and in others the later portion of the tube tends to grow out away from the early coiled portion; periphery rounded; tubular chamber ovate in section; spiral suture depressed, distinct; wall thin, very finely arenaceous with considerable cement, not soluble in acid, surface smooth and hyaline in appearance; aperture subcircular in outline, formed by a slight terminal constriction of the tube; color white.

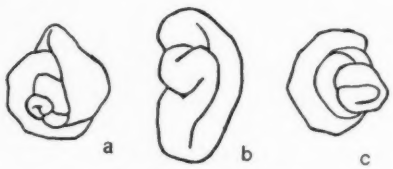


FIG. 1—*Glomospira watersi* Loeblich, n. sp. Paratypes, showing the variation in form of this species. ×76.

Specimens vary in diameter from 0.179 mm. to 0.293 mm. Greatest diameter of holotype 0.221 mm., greatest thickness 0.05 mm., least thickness 0.036 mm., greatest breadth of tubular chamber 0.057 mm. Greatest diameter of figured paratype 0.24 mm.

Types.—Holotype, Cushman Coll. No. 44100 and paratype of fig. 4 Cushman Coll. No. 44101 and paratypes of text figs. 1a–c (Cushman Coll. No. 44102) all from sample 662, at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Loeblich Coll. No. 1030.

Remarks.—This species is distinguished from *Glomospira compressa* Waters by its smaller size and smoother test. While generally planispiral in plan, some specimens of *G. watersi*, n. sp., such as the paratype of fig. 4 of the plate, show a tendency to uncoil as in *Lituotuba*, and suggests the rise of *Lituotuba* from *Glomospira* by a later uncoiling of the spiral chamber. All specimens are from sample 662 and 13 specimens were found.

This species is named in honor of J. A. Waters, in recognition of his work on the Foraminifera of Texas.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMIINAE
Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES PLATUS Loeblich, n. sp.
Plate 22, figures 5a–b

Test free, compressed, planispiral, small, not completely involute, periphery sharp and lobate in outline; chambers numerous, rapidly increasing in size, about six to seven in the last whorl, usually 1½ whorls being visible, as the later chambers do not reach entirely to the center of the test, chambers slightly collapsed centrally, probably originally slightly inflated; sutures distinct, straight, with a very slight backward swing at the periphery, slightly depressed; wall thin, finely arenaceous, insoluble in acid, smoothly finished; aperture a high arch at the base of the apertural face; color white.

Specimens vary in greatest diameter from 0.321 mm. to 0.214 mm. Greatest diameter of holotype 0.257 mm., least diameter 0.207 mm., greatest thickness 0.03 mm.

Types.—Holotype, Cushman Coll. No. 44103 from sample 665, at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44104, and Loeblich Coll. Nos. 1031 and 1032.

Remarks.—This species is similar in size to *Haplophragmoides excavatus* Cushman and Waters, but differs in being much thinner, less involute and in lacking the limbate sutures of *H. excavatus*. The present species

occurs in samples 662 to 665, inclusive, and is represented by 44 specimens.

Genus AMMOMARGINULINA Wiesner, 1931
AMMOMARGINULINA BELLENSIS Loeblich, n. sp.
Plate 22, figures 8a–b

Test free, small, flattened, periphery subacute, early portion planispirally coiled and evolute, later chambers uniserially arranged; chambers numerous, six to seven chambers in the last whorl of the coiled portion, later chambers at first somewhat irregularly uniserial, with the later portion of the test finally becoming rectilinear, chambers increasing rather rapidly in size, uniserial chambers generally with breadth greater than length; sutures distinct, straight or very slightly curved, clear and thickened in the coiled portion and very slightly depressed, but distinctly depressed in the later portion of the test; wall composed of medium-sized grains with considerable cement, but a comparatively rough finish, test insoluble in acid; aperture an elongate terminal slit; color yellowish to white.

Specimens vary in length from 0.257 mm. (coiled portion only), to 0.614 mm. Length of holotype 0.614 mm., greatest diameter of coil 0.164 mm., greatest breadth of uniserial portion 0.236 mm., greatest thickness 0.09 mm.

Types.—Holotype, Cushman Coll. No. 44105 from sample 665 at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44106 and Loeblich Coll. Nos. 1033, 1034 and 1035.

Remarks.—This species differs from *Ammomarginulina subcretacea* (Cushman and Alexander) in the larger chambers and flatter test and smoother finish. It differs from *Ammobaculoides plummerae*, n. sp., in the much larger size, larger diameter of the coiled portion, in possessing an elongate, slit-like aperture, and in lacking the distinct biserial stage of that species, although rarely the irregular early chambers may give an almost biserial appearance.

Ammomarginulina bellensis, n. sp., is represented by 81 specimens and was found in samples 662 to 665, inclusive. Young tests consisting only of the coiled portion are frequently found.

Genus AMMOBACULITES Cushman, 1910
AMMOBACULITES OBSCURUS Loeblich, n. sp.
Plate 22, figures 6a–b

Test free, small, periphery rounded, early portion planispirally coiled, later chambers in a rectilinear series; chambers numerous, gradually increasing in size in the early coiled portion, but increasing very little in the uniserial portion so that the sides are nearly parallel, uniserial chambers low in height; sutures very indistinct in the early portion, straight and slightly depressed in the uniserial portion; wall finely arenaceous, with considerable cement, insoluble in acid, smoothly finished; aperture rounded, terminal; color white.

Specimens vary in length from 0.329 mm. to 0.60 mm. Length of holotype 0.536 mm., greatest diameter of coil 0.221 mm., greatest breadth of uniserial portion 0.186 mm., greatest thickness through coiled portion 0.13 mm., greatest thickness through uniserial portion 0.10 mm.

Types.—Holotype, Cushman Coll. No. 44107 from sample 665 at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44108 and Loeblich Coll. Nos. 1036 and 1037.

Remarks.—This species differs from *Ammobaculites taylorensis* Cushman and Waters in its smaller size, even periphery in the coiled portion, parallel sides in the uniserial part rather than a flaring test, and in having a more rounded cross section in the later part.

Ammobaculites obscurus, n. sp., is represented by 29 specimens and was found in samples 662 to 665, inclusive.

AMMOBACULITES POLYTHALAMUS Loeblich, n. sp.
Plate 22, figures 7a–b; text figure 2

Test free, small, periphery bluntly rounded, early portion planispirally coiled, later chambers in a rectilinear series; chambers numerous and low in the early portion, uniserial chambers much larger, somewhat inflated and about equal in height and breadth, last chamber tapering slightly to the aperture; sutures distinct, straight, depressed; wall finely arenaceous, with considerable cement, insoluble in acid; aperture terminal, rounded; color whitish.

Specimens vary in length from 0.307 mm.

to 0.386 mm. Length of holotype 0.371 mm., greatest diameter of coil 0.171 mm., greatest breadth of uniserial portion 0.136 mm., greatest thickness 0.075 mm.

FIG. 2—*Ammobaculites polythalamus* Loeblich, n. sp. Paratype, showing better uniserial development than the holotype. ×76.

Types.—Holotype (Cushman Coll. No. 44109) and paratype of text fig. 2 (Cushman Coll. No. 44110) from sample 665, at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Loeblich Coll. No. 1038.

Remarks.—This species is similar to *Ammobaculites goodlandensis* Cushman and Alexander in the rough outline, central umbilicus, numerous small chambers in the coil and comparatively large chambers in the uniserial portion, but differs in the much smaller size, comparatively thinner and much more finely arenaceous test. It differs from *A. woolnoughi* Crespin and Parr in the smaller size, more numerous chambers in the coil, higher uniserial chambers and in the tapering of the last chamber toward the aperture. *A. polythalamus*, n. sp., differs from *Haplophragmium australe* Howchin in the smaller size and the greater height of the uniserial chambers.

This species occurs in samples 662 to 665, inclusive, and is represented by 12 specimens.

Family TEXTULARIIDAE
Subfamily SPIROPLECTAMMININAE
Genus SPIROPLECTAMMINA Cushman, 1927
SPIROPLECTAMMINA sp.
Plate 22, figures 9a–b

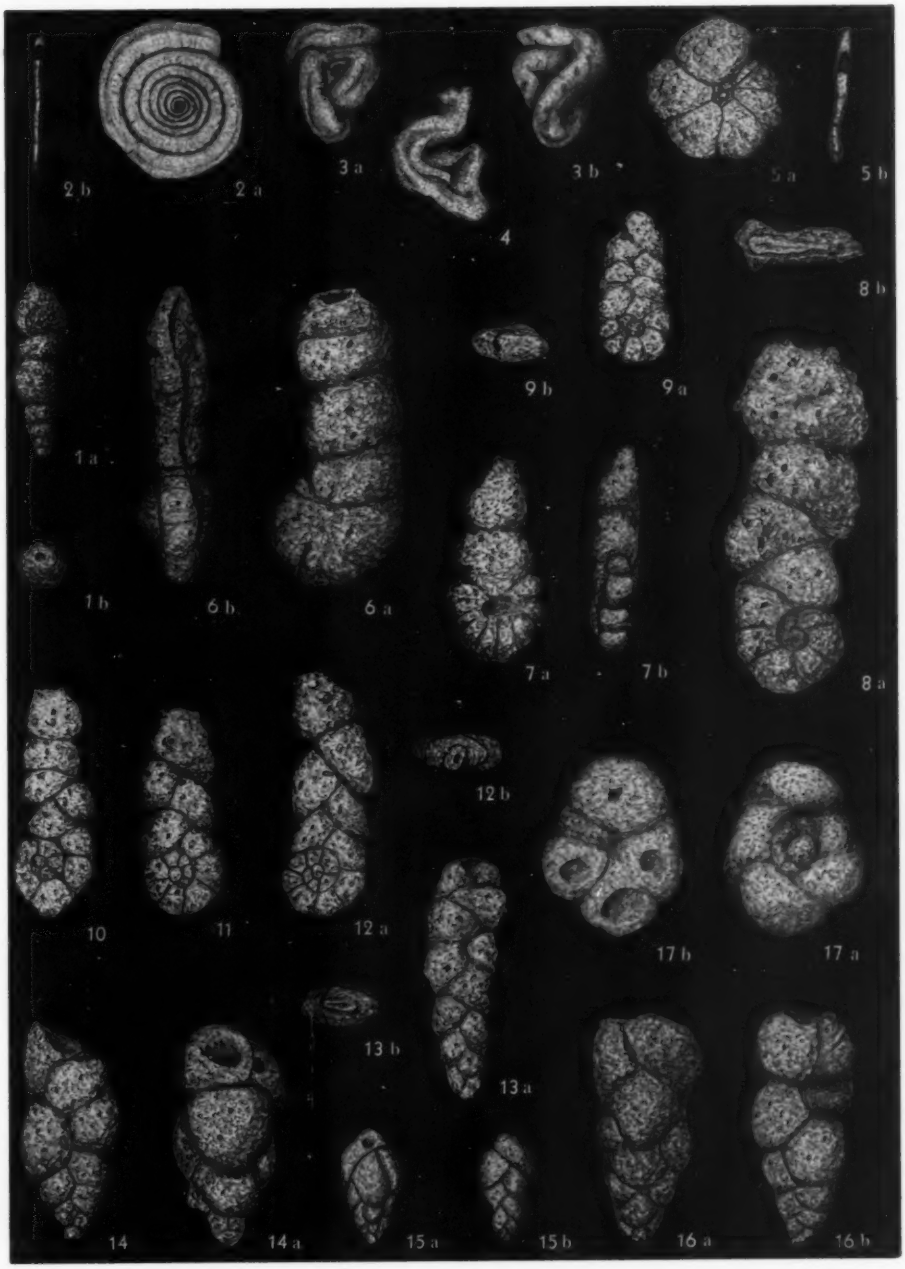
Test free, small, flattened, periphery rounded, early portion planispirally coiled, later biserial; chambers numerous, increasing very slowly in size, uniserial chambers low, with sides of test nearly parallel; sutures distinct, straight, slightly depressed; wall finely arenaceous, with considerable cement, insoluble in acid; aperture at the base of the last formed chamber; color gray.

Figured specimen 0.271 mm. in length, greatest diameter of coiled portion 0.136 mm., breadth across last two chambers 0.10 mm., maximum thickness 0.065 mm.

Types.—Cushman Coll. No. 44111, from sample 663 at the type locality of the Pepper shale, Bell County, Texas.

DESCRIPTION OF PLATE 22

FIGS. *1a–b—Reophax pepperensis* Loeblich, n. sp. *1a*, side view; *1b*, top view of holotype, ×117. (p. 133)
2a–b—Ammodiscus planus Loeblich, n. sp. *2a*, side view; *2b*, edge view of holotype, ×76. (p. 133)
3a–4—Glomospira watersi Loeblich, n. sp. *3a*, dorsal view; *3b*, ventral view of holotype. *4*, Paratype, showing tendency to uncoil, ×76 (p. 134)
5a–b—Haplophragmoides platus Loeblich, n. sp. *5a*, side view; *5b*, edge view of holotype, ×76. (p. 134)
6a–b—Ammobaculites obscurus Loeblich, n. sp. 6a, side view; 6b, edge view of holotype, ×76. (p. 135)
7a–b—Ammobaculites polythalamus Loeblich, n. sp. *7a*, side view; *7b*, edge view of holotype, ×76 (p. 136)
8a–b—Ammomarginulina bellensis Loeblich, n. sp. *8a*, side view; *8b*, apertural view of holotype, ×76. (p. 134)
9a–b—Spiroplectammina sp. *9a*, side view; *9b*, top view, ×76. (p. 137)
10–12b—Ammobaculoides plummerae Loeblich, n. sp. *10*, *11*, side views of paratypes; *12a*, side view of holotype; *12b*, top view, ×76. (p. 137)
13a–b—Textularia adkinsi Loeblich, n. sp. *13a*, side view; *13b*, top view of holotype, ×117. (p. 138)
14–16b—Verneuilina perplexa Loeblich, n. sp. *14a*, apertural view of holotype; *14*, side view of holotype; *15a*, *15b*, *16a*, *16b*, side views of paratypes, ×117. (p. 138)
17a–b—Trochammina wickendeni Loeblich, n. sp. *17a*, dorsal view; *17b*, ventral view of holotype, ×76. (p. 138)



Loeblich—Upper Cretaceous Foraminifera

Remarks.—This species is similar in appearance to *S. mexiaensis* Lalicker in the proportionately large planispiral portion, narrower uniserial portion, and low uniserial chambers, but differs in its somewhat smaller size, slightly higher chambers, more lobate periphery, due to the depression of the sutures, less arched sutures and flatter test, lacking the central ridge of *S. mexiaensis*. It differs from *S. scotti* Cushman and Alexander in being about one-fourth the size of that species, in having a comparatively broader coil, and narrower and nonflaring biserial portion.

This species is represented by a single specimen, hence it is not named until more specimens are available.

Genus AMMOBACULOIDES Plummer, 1932

AMMOBACULOIDES PLUMMERAE Loeblich, n. sp.

Plate 22, figures 10–12b; text figures 3a–g

Test free, small, flattened, periphery acute, early portion planispirally coiled and evolute, later biserial and finally becoming rectilinear; chambers numerous, increasing rapidly in size as added, about seven chambers in the last whorl of the coiled portion generally followed by four to six biserial chambers and then one or two uniserial chambers, uniserial chambers somewhat pyriform in outline, some specimens with more biserial chambers and fewer or no uniserial chambers, and others with a reduced biserial portion and more of the uniserial chambers; sutures in the coiled portion straight, fairly distinct, particularly when the specimen is dampened, as the thickened sutures are then more noticeable, later sutures distinct and depressed, giving the test a lobate outline; wall arenaceous, composed of clear quartz grains with a very small amount of cement, insoluble in acid; aperture terminal on the last formed chamber; color whitish.

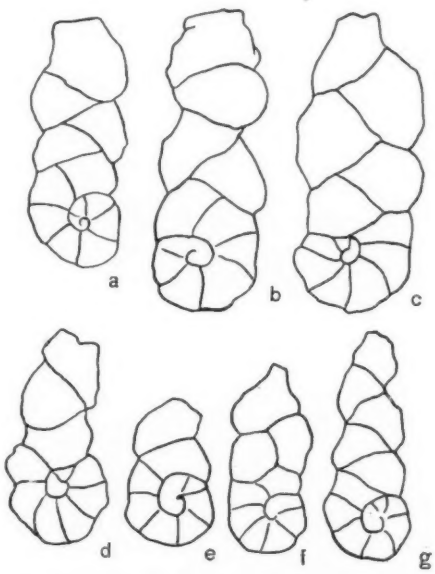


FIG. 3—*Ammobaculoides plummerae* Loeblich, n. sp. Paratypes, showing variation in size and degree of biserial and uniserial development. ×76.

Length varies from 0.25 mm. to 0.493 mm. Length of holotype 0.443 mm., greatest breadth of coil 0.150 mm., thickness 0.062 mm. Length of paratype in fig. 10, 0.421 mm., length of paratype in fig. 11, 0.371 mm.

Types.—Holotype, Cushman Coll. No. 44112, paratypes of fig. 10 Cushman Coll. No. 44113, of fig. 11, Cushman Coll. No. 44114 and of text figs. 3a–g, Cushman Coll. No. 44115, all from sample 665 at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44116, and Loeblich Coll. Nos. 1039 and 1040.

Remarks.—This species differs from *A. navarroensis* Plummer in the more distinct coil, which is evolute and larger in diameter than the biserial portion of the test, in the biserial chambers increasing more slowly in size as added, in having higher uniserial chambers and in the pyriform appearance of the last chamber, due to the presence of a slight neck.

The characters of this species support the evolution of *Ammobaculoides* from *Spiroplectammina*, so that it is placed in the family Textulariidae, as in Cushman (1940), rather than in the Lituolidae, where the genus was originally placed by Plummer, or the Trochamminidae, where it was placed by Galloway (1933).

This species is the most common form in the Pepper, approximately 700 specimens having been obtained from the type sample, No. 665, in which it is most abundant. It is

also found in samples 662 to 664, inclusive.

Ammobaculoides plummerae, n. sp., is named in honor of Mrs. Helen Jeanne Plummer, in recognition of her work on the Texas foraminifera.

Subfamily TEXTULARIINAE
Genus TEXTULARIA Defrance, 1824
TEXTULARIA ADKINSI Loeblich, n. sp.
Plate 22, figures 13a–b

Test free, narrow, tiny and biserial, periphery rounded; chambers numerous, increasing gradually in size as added, but later chambers having comparatively less height; sutures distinct, depressed, early ones at an angle, later ones nearly horizontal; wall finely arenaceous, composed of clear quartz grains with considerable cement, insoluble in acid; aperture elongate, in the apertural face; color white.

Length of holotype 0.271 mm., greatest breadth 0.093 mm., greatest thickness 0.053 mm. Length of specimens varies from 0.229 mm. to 0.307 mm.

Types.—Holotype, Cushman Coll. No. 44117 from sample 663, at the type locality of the Pepper shale, in Bell County, Texas. Paratypes, Cushman Coll. No. 44118 and Loeblich Coll. No. 1041.

Remarks.—This species is quite distinctive and not similar in appearance to any described species. It is closest to *T. wiesneri* Earland, from which it differs in having an elongate aperture, rather than an arch at the base of the last chamber, and in being only about ⅔ the size of *T. wiesneri*.

This species is represented by only six specimens, from sample 663. It is named in honor of W. S. Adkins, in recognition of his work on the stratigraphy of the Texas Cretaceous.

Family VERNEUILINIDAE
Genus VERNEUILINA d'Orbigny, 1840
VERNEUILINA PERPLEXA Loeblich, n. sp.
Plate 22, figures 14–16b

Test free, tiny, triserial throughout; chambers numerous, inflated, increasing rapidly in size as added, later chambers almost globular; sutures distinct, depressed; wall arenaceous, composed of clear quartz grains with a large amount of cement, insoluble in acid, surface smoothly finished; aperture comparatively large, at the base of the last formed chamber in the young specimens, later is found in the apertural face of the last formed chamber; color white.

Length varies from 0.136 mm. to 0.350 mm. Length of holotype 0.257 mm., greatest breadth 0.129 mm.; length of paratype in fig. 15, 0.136 mm., greatest breadth 0.071 mm.; length of paratype in fig. 16, 0.271 mm., greatest breadth 0.114 mm.

Types.—Holotype, Cushman Coll. No. 44119 from sample 665, paratype of fig. 15, Cushman Coll. No. 44120 from sample 663, paratype of fig. 16, Cushman Coll. No. 44121 from sample 664, all from the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44122 and Loeblich Coll. Nos. 1042 and 1043.

Remarks.—This species is most similar to *V. polystropha* (Reuss), but differs in having more inflated chambers, and in the adult having a rounded aperture in the face, rather than at the base of the chamber.

Verneuilina perplexa, n. sp., shows some resemblance to *Tritaxia*, in tending to have a nearly terminal aperture in well-developed specimens. However it is distinctly triserial and no uniserial stages have been seen. It also lacks the characteristic triangular section of *Tritaxia*.

This species occurs in samples 663, 664 and 665, and is represented by 96 specimens.

Family TROCHAMMINIDAE
Subfamily TROCHAMMININAE
Genus TROCHAMMINA Parker and Jones, 1859
TROCHAMMINA WICKENDENI Loeblich, n. sp.
Plate 22, figures 17a–b

Test free, tiny, trochoid, flattened, ventrally umbilicate, convex dorsally, periphery subacute; chambers numerous, increasing rapidly in size as added, up to the last whorl, then increasing more slowly, five chambers in the last whorl, chambers frequently partially collapsed centrally; sutures distinct, depressed, slightly curved backward from the aperture on the dorsal side, nearly straight on the ventral side; wall thin, finely arenaceous, with considerable cement, insoluble in acid, surface

smoothly finished, giving an almost hyaline appearance; aperture at the inner margin of the ventral side of the last formed chamber; color whitish.

Specimens vary in diameter from 0.179 mm. to 0.407 mm. Greatest diameter of holotype 0.264 mm., least diameter 0.231 mm., greatest thickness 0.079 mm.

Types.—Holotype, Cushman Coll. No. 44123 from sample 665, at the type locality of the Pepper shale, Bell County, Texas. Paratypes, Cushman Coll. No. 44124, and Loeblich Coll. Nos. 1044 and 1045.

Remarks.—This species is similar in size to *T. albertensis* Wickenden, from the Bearpaw shale of Canada, but is not nearly as conical, has depressed sutures, fewer chambers and a sharper periphery. It differs from *T. arenosa* Cushman and Waters in the smaller size, flatter test, curved sutures, and in possessing more chambers in the last whorl.

This species occurs abundantly in samples 662 to 665, inclusive, and is represented by approximately 265 specimens. It is named in honor of R. T. D. Wickenden, in recognition of his work on the Cretaceous Foraminifera of Canada.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 2, PP. 140–157, PLS. 23–26, 1 TEXT FIG., MARCH 1946

PERMIAN FUSULINIDS FROM AFGHANISTAN

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ABSTRACT—Four species and one variety of fusulinids from the Bamian limestone of northern Afghanistan are described and illustrated as *Yangchienia haydeni*, n. sp., *Schwagerina furoni*, n. sp., *Polydiexodina afghanensis*, n. sp., *Afghanella schencki*, n. sp., and *Neoschwagerina craticulifera haydeni* Doutkevitch and Khabakov. The new genus *Afghanella* is proposed, with *A. schencki* as the genotype. Earlier workers have demonstrated that a species of the genus *Verbeekina* Staff is associated in the Bamian limestone with the above forms. This is the first time the American upper Guadalupian Permian fuslinid genus *Polydiexodina* Dunbar and Skinner has been identified associated with the verbeekinids and neoschwagerinids of the Tethys Sea fusulinid faunas of Europe and Asia. The association of *Polydiexodina* with a typical Tethys Sea fusulinid fauna of the zone of *Verbeekina-Neoschwagerina* strongly suggests that this Tethys Sea fusulinid faunal zone is equivalent in age, at least in part, to the upper Guadalupian of North America.

INTRODUCTION AND ACKNOWLEDGMENTS

FUSULINID Foraminifera are abundant throughout most of the Pennsylvanian and the marine part of the Permian rocks throughout the world. The major divisions of all rocks of Pennsylvanian age and the lower divisions of rocks of Permian age of the Eastern and Western Hemispheres can be correlated with some degree of certainty by the use of fusulinids. However, the upper part of the fusulinid-bearing Permian rocks of most parts of North America contains fusulinid faunas that are markedly different from those found in the upper fusulinid-bearing part of the Permian of the Eastern Hemisphere and extreme northwestern North America. The faunas of the latter area are known to occur in a relatively narrow belt from the Mediterranean Sea area of Europe and Africa, across southern Asia, and into extreme western Canada and northwestern United States. The Permian sea in which they lived generally is referred to as the Tethys Sea. The Tethys Sea fusulinid faunas are dominated by species of the subfamilies Verbeekininae and Neoschwagerininae. The uppermost fusulinid faunas of the typical American Permian are dominated by species of the genus *Polydiexodina* of the subfamily Schwagerininae. The genus *Polydiexodina* has not been identified previously associated with any elements of the Tethys Sea faunas. Therefore, the stratigraphic relationship between the Zone of *Polydiexodina* of the American Permian and the fusulinid faunas of the Tethys Sea has not been clearly understood.

In 1909 Hayden studied the fusulinid fauna of the Bamian limestone of Afghanistan from which he identified the following forms:

Fusulina uralica Krotow
F. elongata Shumard
Schwagerina princeps (Ehrenberg)
Neoschwagerina craticulifera (Schwager)
N. (*Cancellina*) *primigena* Hayden
N. annae (Volz)

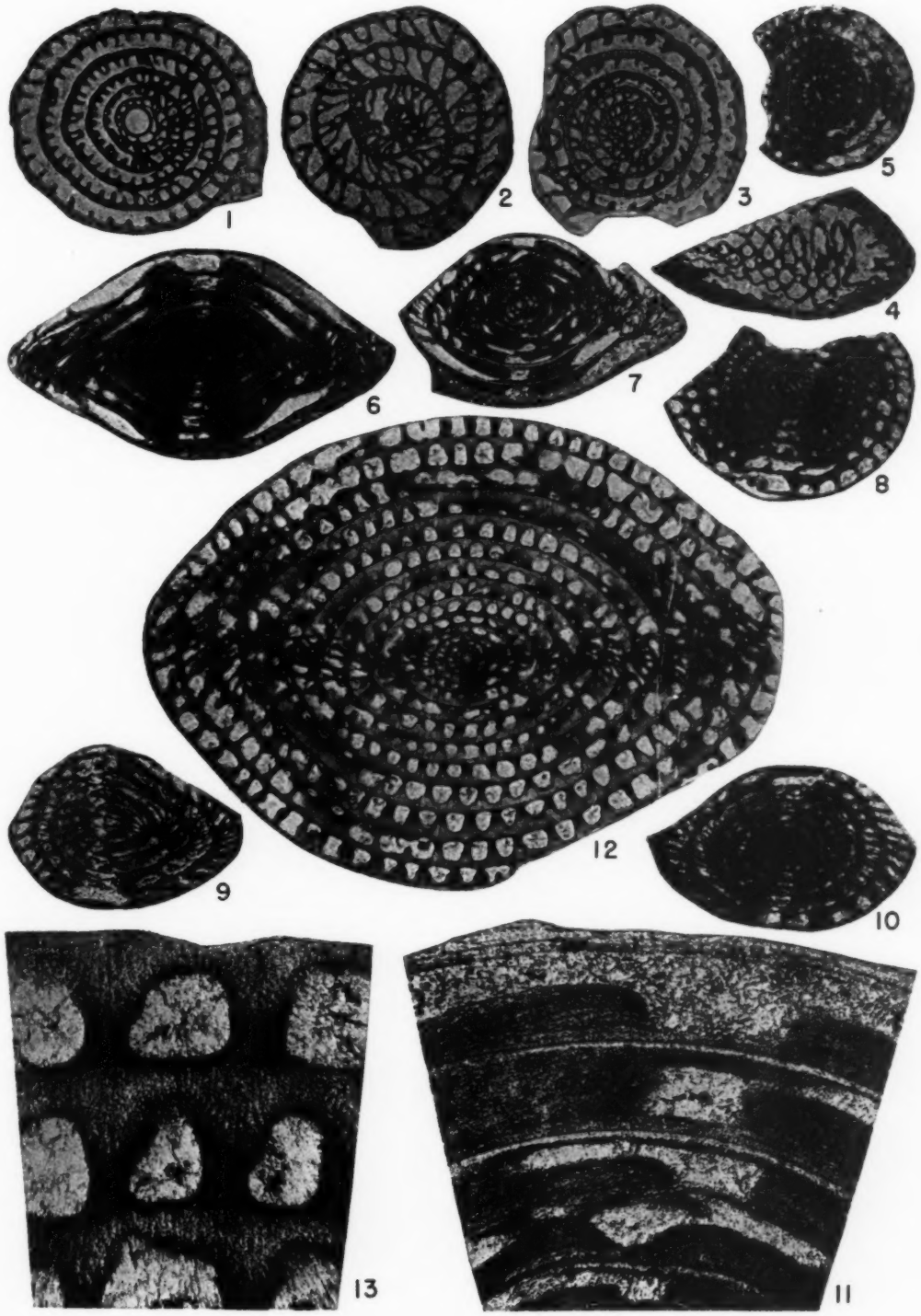
EXPLANATION OF PLATE 23

All illustrations on this plate are unretouched photographs.

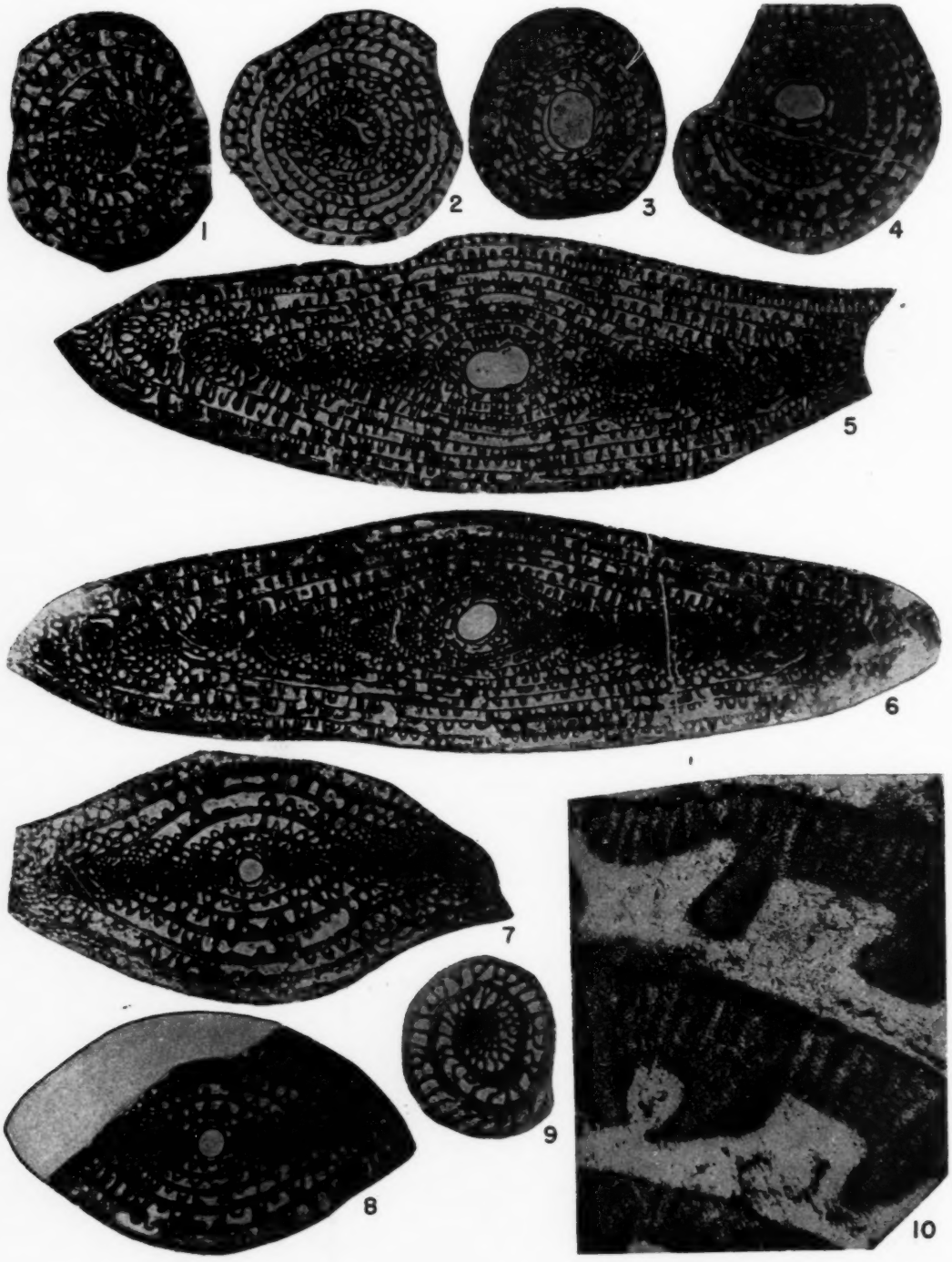
FIGS. *1–4*—*Schwagerina furoni* Thompson, n. sp. *1*, Sagittal section of a paratype, ×10; *2*, *3*, parallel sections of paratypes, ×10; *4*, parallel section of a paratype that shows poorly developed cuneculi, ×10. Bamian limestone, Afghanistan. (p. 147)

5–11—*Yangchienia haydeni* Thompson, n. sp. *5*, Parallel section of a paratype, ×20; *6*, axial section of the holotype, ×20; *7*, axial section of a paratype, ×20; *8*, *9*, oblique sections of paratypes, ×20; *10*, oblique axial section of a paratype, ×20; *11*, enlarged portion of the axial section illustrated as 7 that shows the structure of the spirotheca and chomata, ×1000. Bamian limestone, Afghanistan. (p. 146)

12, *13*—*Neoschwagerina craticulifera haydeni* Doutkevitch and Khabakov. *12*, Axial section, ×20; and *13*, enlarged portion of the illustrated axial section that shows the structure of the spirotheca and of the transverse septula, ×100. Bamian limestone, Afghanistan. (p. 155)



Thompson—Afghan Fusulinids



Thompson—Afghan Fusulinids

Although Hayden's report was one of the most highly detailed studies of the fusulinids published up to that time, it is obvious from the illustrations that many of his generic and specific references are not correct as the fusulinids are now classified. Shell structures now believed to be of importance in the proper classification of species and genera of fusulinids were not observed at this early date. The exact nature of several of the forms studied by Hayden has long been in doubt, particularly the detailed features of the form described by him as *Fusulina elongata* Shumard. Two years later Hayden (1911) discussed the geology of the fusulinid-bearing Permian of Afghanistan and indicated the forms he identified as *Fusulina elongata* and *F. uralica* occur stratigraphically below the other fuslinids.

In 1927, Furon obtained fusulinids from the Bamian limestone at numerous localities in northern Afghanistan. He listed the following fusulinids from that region:

Neoschwagerina craticulifera (Schwager)
N. (*Sumatrina*) *annae* Volz
N. primigena Hayden
Doliolina lepida (Schwager)
Schwagerina verbeeki (Geinitz)
S. princeps (Ehrenberg)
Fusulina elongata Shumard
F. uralica Krotow.

Furon also indicated that the forms he identified as *Fusulina uralica* and *F. elongata* occurred stratigraphically below the other fusulinids. He did not describe his collections and there is some uncertainty as to the exact nature of part of them.

Large collections of fusulinids were obtained from the Bamian limestone by members of exploration parties sent into southern Asia by the Inland Exploration Company and Amiranian Oil Company. These collections were sent to me for study by Professor H. G. Schenck, a member of one of these parties.

A detailed study of thin sections prepared from this material, together with an examination of Hayden's illustrations and descriptions, demonstrates that the fusulinid fauna of the Bamian limestone includes the following forms, part of which are described and illustrated below:

Yangchienia haydeni, n. sp.
Schwagerina furoni, n. sp.
Polydiexodina afghanensis, n. sp.
Verbeekina verbeeki (Geinitz)?
Cancellina primigena Hayden
Neoschwagerina craticulifera haydeni Doutkevitch and Khabakov
Afghanella schencki, n. sp.

Representatives of *Cancellina primigena* and *Verbeekina verbeeki*? were not identified from the collections I am studying. The form identified by Hayden as *Schwagerina princeps* almost certainly is a species of *Verbeekina*. However, as Furon listed both *Verbeekina verbeeki* and *S. princeps*, it is possible he had a species of *Paraschwagerina*. As is obvious by a comparison of the above list with Hayden's identifications, many of Hayden's generic and specific references are not in accordance with the present classification of the fusulinids. Both Hayden (1911) and Furon (1927) indicated that the form they referred to *F. elongata* (= *Polydiexodina afghanensis*, n. sp.) occurs stratigraphically below the species of neoschwagerinids and verbeekinids. However, the collections I have demonstrate beyond any doubt that *P. afghanensis* is associated in the same stratum with all of the species I am describing and illustrating below. All five of the forms I am illustrating were found in the same limestone sample.

This is the first locality at which *Polydiexodina* has been found in direct association with Tethys Sea fusulinid fauna of verbeekinids and neoschwagerinids. This

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EXPLANATION OF PLATE 24

FIGS. *1–6*—*Polydiexodina afghanensis* Thompson, n. sp. *1*, *2*, Parallel sections of paratypes, ×10; *3*, *4*, sagittal sections of paratypes, ×10; *5*, *6*, axial sections of paratypes, ×10. Bamian limestone, Afghanistan. (p. 150)

7–10—*Schwagerina furoni* Thompson, n. sp. *7*, Axial section of the holotype, ×10; *8*, axial section of a paratype, ×10; *9*, parallel section of a paratype, ×10; and *10*, enlarged portion of a paratype (pl. 23, fig. 3) that shows the structure of the spirotheca and septa, ×100. Bamian limestone, Afghanistan. (p. 147)

association furnishes one of the first definite clues based on fusulinids as to the relative stratigraphic ages of the "standard" section of the American Permian and the Permian of the Tethys Sea area of the Eastern Hemisphere and extreme northwestern North America. Therefore, it is important that this Afghan fauna be described in detail and its classification brought up to date.

I wish to express my sincere thanks to Professor Schenck for the opportunity to study these collections, and to Mr. John M. Lovejoy, President of Seaboard Oil Company, for permission to publish this report.

PERMIAN FUSULINID FAUNAL ZONES

Fusulinid-bearing Lower Permian rocks (Wolfcampian series of America, Sakmarian series of Russia, Taiyuan series of China, and rocks of equivalent age in other areas) have been recognized in North America, Europe, and Asia, on many of the western Pacific islands, and on many islands of the Arctic region. Throughout most of this wide geographic distribution, this part of the stratigraphic section is characterized by the presence of species of the genus *Pseudoschwagerina* Dunbar and Skinner and is referred to paleontologically as the Zone of *Pseudoschwagerina*. This fusulinid faunal zone is by far the most widespread geographically of any so far designated for the Permian. Associated with *Pseudoschwagerina* are species of many other genera of fusulinids, including *Schubertella* Staff and Wedekind, *Triticites* Girty, *Schwagerina* Möller, *Paraschwagerina* Dunbar and Skinner, and primitive species of *Parafusulina* Dunbar and Skinner. However, *Pseudoschwagerina* is the only genus confined to this part of the stratigraphic section.

Throughout large parts of the United States, northern Mexico, and Central America rocks of Wolfcampian age are followed upward by rocks (Leonardian and lower Guadalupian) that contain prolific fusulinid faunas composed largely of species of the genus *Parafusulina* Dunbar and Skinner. This part of the Permian in America is designated the zone of *Parafusulina*.

In South China, rocks (Maping limestone) that contain fusulinids of the zone of *Pseudoschwagerina* (Chen, 1934) are overlain by rocks (Swine limestone and lower and middle Chihsia limestone) that contain a fusulinid fauna composed largely of species of *Parafusulina*. However, the upper part of the Chihsia limestone of southern China contains a fusulinid fauna composed of species of the genera *Nankinella* Lee, *Yangchienia* Lee, *Misellina* Schenck and Thompson, *Cancellina* Hayden, *Pseudodoliolina* Yabe and Hanzawa, *Eoverbeekina* Lee, and *Verbeekina* Staff.

Parafusulina has been recognized at only a few other localities in Europe and Asia (Dunbar, 1933), but this genus probably is much more widespread geographically in the Eastern Hemisphere than is now known. *Parafusulina* is most easily recognized by a study of tangential thin sections or polished sections, but tangential sections were seldom included in reports published prior to 1930. Therefore, it is probable that many more species of *Parafusulina* have been described than are now recognizable as such.

The upper part of the Guadalupian series of south central United States and northern Mexico contains a prolific fusulinid fauna composed almost entirely of species of the genus *Polydiexodina* Dunbar and Skinner. That part of the section is therefore designated as the zone of *Polydiexodina*.

Rocks of upper Permian age that contain a large fusulinid fauna of the subfamilies Verbeekininae and Neoschwagerininae occur in a narrow belt that extends from the eastern part of the Mediterranean Sea area (Tunis on the south and Sicily on the north) of Africa and Europe, across Asia Minor, across southern Asia and Japan, and from British Columbia to Oregon in northwestern North America. This Upper Permian faunal assemblage is not found in any part of the world outside this narrow belt. The seaway in which it lived is referred to as the Tethys Sea. Only one primitive species of the subfamily Verbeekininae, *Eoverbeekina americana* Thompson and Miller from Chiapas, Mexico, has been discovered outside the Tethys Sea area, and no species of the subfamily Neoschwagerininae has been discovered outside this area.

The evolutionary succession of the fusulinids in the Tethys Sea Upper Permian has not been satisfactorily determined. However, it seems probable that in Asia the north-south geographic distribution of the

more primitive elements was wider than the north-south distribution of the later and more highly developed elements.

One of the most primitive assemblages of the Tethys Sea fusulinid faunas is found in the upper part of the Chihsia limestone of southern China (Chen, 1934). The lower and middle parts of the Chihsia limestone contain a large fauna of the genus *Parafusulina* that resembles remarkably closely the fauna of the American zone of *Parafusulina*. The fauna in the upper part of the Chihsia limestone contains representatives of the genera *Yangchienia* Lee, *Nankinella* Lee, *Eoverbeekina* Lee, *Verbeekina* Staff, *Pseudodoliolina* Yabe and Hanzawa, *Misellina* Schenck and Thompson, and *Cancellina* Hayden. In many other regions of the Tethys Sea, fusulinid faunas composed of these same genera, with the addition of *Afghanella*, n. gen., *Schubertella* Staff and Wedekind, *Sumatrina* Volz, and *Neoschwagerina* Yabe, occur in rocks of about the same age or only slightly younger than the upper part of the Chihsia limestone. Such Tethys Sea faunas have been described from many areas, including Sicily (Silvestri, 1933), Aegean Islands of Greece (Ozawa and Tobler, 1929), Pamir (Doutkevitch, 1934), Asia Minor (Chaput, 1932), Darwas (Licharew, 1939), Sumatra (Lange, 1925), Island of Letti (Schubert, 1915), western Szechuan, China (Thompson and Foster, 1937), Karakorum (Silvestri, 1935), French Indo-China (Deprat, 1912, 1913; Gubler, 1935), and Japan (Deprat, 1914; Ozawa, 1925, 1927; and Huzimoto, 1936).

Representatives of the genera *Verbeekina* and *Neoschwagerina* have been found in practically all these lower Tethys Sea faunas, and that part of the stratigraphic section may be referred to paleontologically as the zone of *Verbeekina-Neoschwagerina*.

The stratigraphically highest fusulinid faunas found in the Tethys Sea area contain representatives of the genus *Yabeina* Deprat, undoubtedly the most highly developed of the fusulinids. In many regions *Yabeina* is the only genus represented in these upper fusulinid faunas. This part of the stratigraphic section has been designated the zone of *Yabeina*. The geographic distribution of this genus was discussed at some length recently by Thompson and Wheeler (1942). It should perhaps be emphasized that, although *Yabeina* is present in the youngest fusulinid faunas from the Permian, in some regions at least a thick section of rocks considered to be of Permian age occurs above the highest occurrence of *Yabeina* (Douvillé, 1934).

Representatives of *Yabeina* have been reported or described from Tunis (Douvillé, 1934), Crimea (Thompson and Wheeler, 1942), French Indo-China (Deprat, 1912, 1913; Gubler, 1935), south China (Lee and Choa, 1924), Japan (Deprat, 1914; Ozawa, 1925, 1927; Huzimoto, 1936), and British Columbia, Washington, and Oregon (Thompson and Wheeler, 1942).

As the above discussion indicates, the Permian of America can be conveniently divided faunally into the zone of *Pseudoschwagerina*, zone of *Parafusulina*, zone of *Polydiexodina*, and zone of *Yabeina*. The zone of *Pseudoschwagerina* is almost worldwide in geographic distribution. The zone of *Parafusulina* occurs above the zone of *Pseudoschwagerina* in North America and in several localities of Europe and Asia. It is believed that a restudy of previously described fusulinid faunas will demonstrate that *Parafusulina* is even more widely distributed in Europe and Asia than is now known.

In the south China region, the Tethys Sea fusulinid faunal zone of *Verbeekina-Neoschwagerina* occurs in the upper part of the Chihsia limestone stratigraphically above the part of the Chihsia limestone containing a typical fusulinid fauna of *Parafusulina*. However, in few other areas are Permian fusulinid faunas known from immediately below the lower Tethys Sea fusulinid faunal zone. Therefore, one of the most outstanding problems in regard to the correlation of Upper Permian fusulinid faunas has been the determination of the stratigraphic relationship between the Guadalupian zone of *Polydiexodina* and the Tethys Sea faunal zones of *Verbeekina-Neoschwagerina* and *Yabeina*. The fact that fusulinids of the zone of *Verbeekina-Neoschwagerina* occur in the upper part of the Chihsia limestone above a prolific fauna of *Parafusulina* would suggest that the former is equivalent in age to the upper part of the American zone of *Parafusulina* or to the zone of *Polydiexodina*.

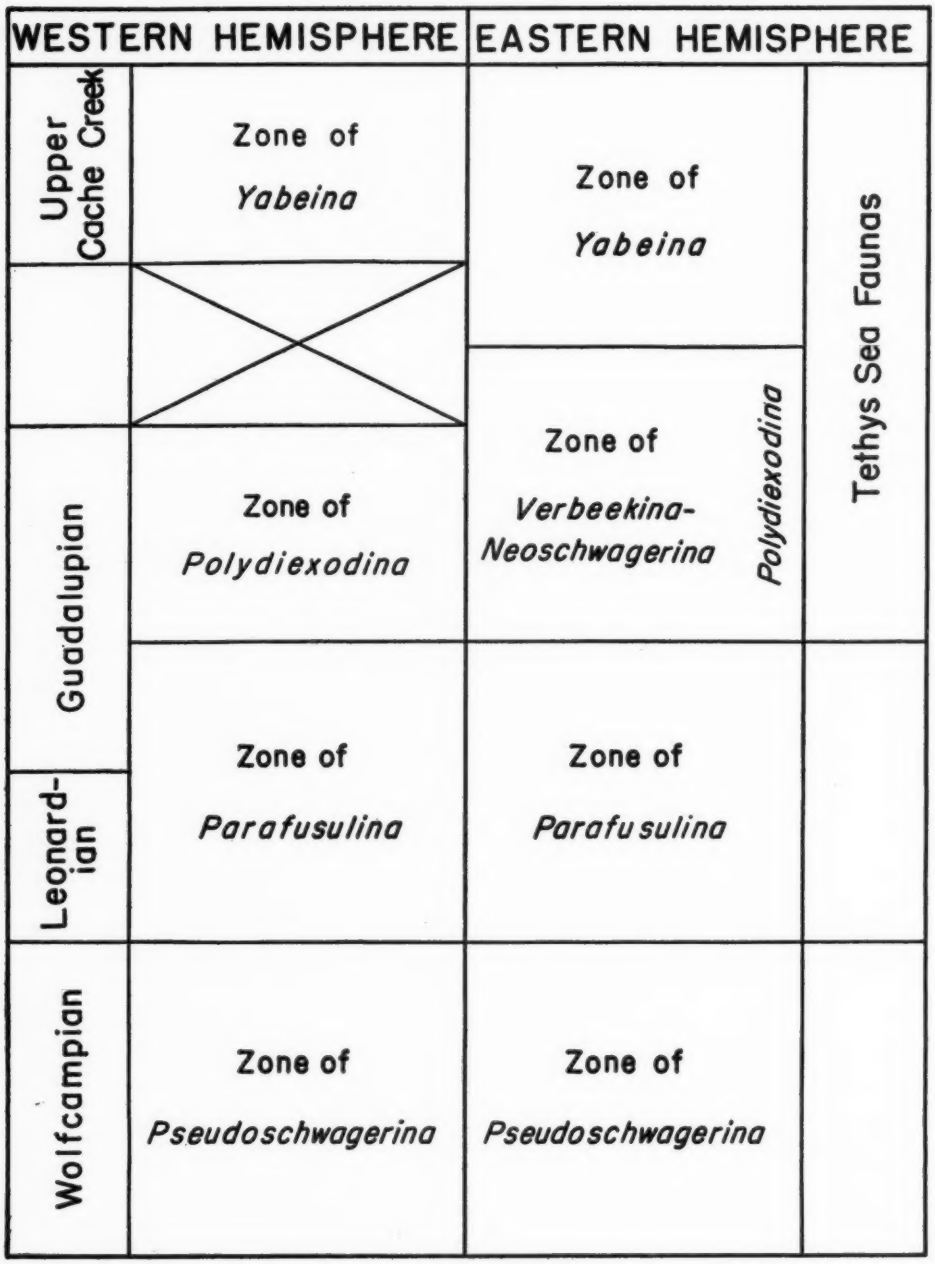


FIG. 1—Suggested correlation of fusulinid faunas between the Eastern Hemisphere and the Western Hemisphere.

The collections I am studying from Afghanistan contain representatives of the fusulinid genera *Yangchienia* Lee, *Neoschwagerina* Yabe, *Afghanella*, n. gen., *Polydiexodina* Dunbar and Skinner, and *Schwagerina* Möller. Also, the thin section of Bamian limestone illustrated by Furon (1927), from the same or a nearby locality, demonstrates a species of *Verbeekina* Staff is associated with the same species of *Neoschwagerina* and *Afghanella* described below. The presence of a species of *Polydiexodina* associated with a typical fauna of the Tethys Sea Zone of *Verbeekina-Neoschwagerina* would seem to substantiate the conclusion that this lower Tethys Sea fusulinid faunal zone is equivalent in age to the American Guadalupian Zone of *Polydiexodina*. Furthermore, if the Zone of *Verbeekina-Neoschwagerina* is equivalent in age to the upper Guadalupian Zone of *Polydiexodina*, it would seem evident that the Zone of *Yabeina* in Africa, Europe, Asia, and northwestern North America is younger stratigraphically than the upper part of the Guadalupian of northern Mexico and southern United States. The suggested correlation between the Tethys Sea fusulinid faunal zones and the fusulinid faunal zones of the "standard" Permian section of America is shown in the accompanying chart (fig. 1).

COLLECTION LOCALITY AND LOCAL STRATIGRAPHY

Hayden (1909) indicated in the introduction to his paper that the Bamian limestone was known at two general localities "in the precipitous gorge through which runs the road from Shibar Pass to Balula and again in the ravine known as 'dara-i-Khojagar' at about 4 miles to the north-northeast of Taibut, the headquarters of the Bamian district." Under the description of "*Fusulina uralica* Krotow" the locality was given as "at about 4 miles north-northeast of Taibut." However, Hayden did not state from which of these two localities the other fusulinids he described were obtained.

The collections I am describing below all were obtained 7 miles from the Bamian road fork on the road to Kabul, or 7 kilometers westerly from the summit of Shibar Pass, approximately 34° 55′ north latitude, 68° 18′ east longitude (Greenwich).

Some of the samples contain abundant specimens of the species described below as *Polydiexodina afghanensis*, n. sp., and common specimens of all the other species described below. Other samples I am studying contain scattered specimens of *P. afghanensis* and scattered specimens of the other species. All of the specimens I am illustrating came from the samples with abundant specimens of *P. afghanensis*. Professor Schenck tells me that all of the collections he obtained from this locality were from the same stratum.

Under the specific description of "*Fusulina elongata*" [=*P. afghanensis* (part)], Hayden pointed out that specimens he was referring to that form occurred at "two horizons," one immediately above and the other immediately below the horizon of *Productus punctatus* Martin. He pointed out that the specimens from the lower level are larger in size and contain more volutions than the higher specimens. Hayden's illustrated external views and some of his illustrated thin sections show a form that is more highly elongate, more slender, and presumably contains fewer volutions than the specimens I am studying. However, some of his illustrated thin sections seem to be closely similar to the specimens I am studying. It is therefore presumed to be possible that I am studying material from the same horizon as part of Hayden's specimens.

Furon (1927) stated that the Bamian limestone contains two zones of fusulinids, the lower of which the elongate forms here referred to the genus *Polydiexodina* and the upper of which contains a neoschwagerinid fauna. The sample I am studying came from Furon's Locality 2 or from a nearby locality. Furon illustrated a section of limestone from this locality that contains specimens of *Schwagerina furoni* (?), n. sp., *Verbeekina* sp., *Neoschwagerina craticulifera* var. *haydeni* Doutkevitch and Khabakov, and *Afghanella schencki*, n. sp. However, Furon did not report the form described below as *P. afghanensis*, n. sp., from this locality. Furon also listed *Schwagerina princeps* (Ehrenberg) from this region. The nature of the specimen identified as *S. princeps* is not known.

SYSTEMATIC DESCRIPTIONS

Genus YANGCHIENIA Lee

YANGCHIENIA HAYDENI Thompson, n. sp.

Plate 23, figures 5–11

Shell minute, inflated fusiform; with sharply pointed poles, straight axis of coiling, and straight to slightly concave lateral slopes. Mature specimens of eight and one-half to nine and one-half volutions measure 2.52 to 2.88 mm. in length and 1.26 to 1.53 mm. in width, giving a form ratio of 1:1.9 to 1:2.0. The first one to two volutions have a short axis of coiling that is at an angle as great as 90° to the axis of the outer fusiform volutions. The first two to three volutions beyond this asymmetrical early stage are elliptical in axial section. Beyond the fourth or fifth volution, the poles are extended and the shell is distinctly fusiform in shape. The form ratios of the first to the tenth volution of two specimens are 1:0.6 to 1:0.66, 1:0.6 to 1:1.3, 1:1.3 to 1:1.4, 1:1.4 to 1:1.5, 1:1.6, 1:1.8, 1:2.0, 1:2.0, and 1:1.9, respectively. As these figures indicate, the outer three to four volutions of mature specimens are of essentially uniform shape.

The proloculum is minute. Its outside diameter measures 57 to 81 microns in four specimens, averaging 72 microns. The inner two volutions are tightly coiled, and the volutions gradually increase in height from the third volution to maturity. The average heights of the first to the tenth volution immediately over the tunnel in ten specimens measure 35, 37, 44, 51, 65, 89, 95, 125, 144, and 150 microns, respectively. The heights of the chambers are essentially the same throughout the length of the shell.

The septa are thin and they are formed by the downward deflection of the tectum and the lower less dense layers of the spirotheca. Relatively thick layers of dense material similar to the chomata cover both sides of the septa in all except the last chambers of the outermost volution. The septa are unfluted throughout the length of the shell. The septal count of the first volution is about 10, and that of the second volution is about 13. The average septal counts of the fourth to the ninth volution of two specimens are 20, 24, 30, 31, 29, and 32, respectively.

The spirotheca is thick. In the penultimate and earlier volutions of mature specimens, the spirotheca is composed of five layers in the central part of the shell (*See* pl. 23, fig. 11). However, in the outer part of the last volution, the spirotheca is composed of only two layers, a thin upper tectum and a lower transparent layer, the diaphanotheca. It is of essentially uniform thickness throughout most of the length of the shell. In the inner volutions, the diaphanotheca is underlain by a thick layer of

TABLE OF MEASUREMENTS (in millimeters) OF YANGCHIENIA HAYDENI

Specimen	L.	W.	Ratio	No. of volutions	Diam. of prol.	Height of volutions 1	2	4	5	6	7	8	9	10
1	2.88	1.53	1.9	9½	.081	.049	.036	.046	.061	.080	.095	.125	.136	.150
2	—	1.22	—	8½	.057	.028	.036	.051	.060	.087	.101	.130	.141	—
3	2.52	1.26	2.0	8½	.085	.036	.040	.061	.081	.101	.090	.121	.154	—
6	0.72	0.57	—	5½	.065	.027	.034	.047	.057	—	—	—	—	—

	Form ratio of volutions 1	2	3	4	5	6	7	8	9	Thickness of spirotheca 0	1	2	3	4	5	7	8	9	10
1	0.6	1.3	1.4	1.5	1.6	1.8	2.0	2.0	1.9	—	—	—	—	—	—	—	—	—	—
2	0.66	0.6	1.3	1.4	—	—	—	—	—	—	—	—	.009	.013	.018	.028	.036	.032	.036
3	—	—	—	—	—	—	—	—	—	.012	.008	.008	.016	.028	.032	.044	.044	.036	—

	Septal count 1	2	3	4	5	6	7	8	9	Tunnel angle (degrees) 1	2	3	4	5	6	7	8	9
1	—	—	—	—	—	—	—	—	—	—	—	11	17	18	20	22	25	25
3	—	—	—	—	—	—	—	—	—	—	—	—	11	15	13	16	16	20
4	—	—	—	16	22	26	28	29	—	—	—	—	—	—	—	—	—	—
5	—	—	—	24	26	34	34	28	32	—	—	—	—	—	—	—	—	—
6	10	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

dense material that resembles the chomata and probably was deposited contemporaneously with the chomata. In the inner part of the shell near the tunnel, the tectum is overlain by two thick layers of material that is slightly less dense than the diaphranotheca. Although these layers are composed of almost identical material and are of about the same thickness, they are separated by a thin layer of dense material that suggests they were formed at different times. A similar spirothecal structure has been observed in congeneric specimens from southern Europe, and it is believed to be characteristic of the genus *Yangchienia*. The diaphanotheca is best developed in the outer five to six volutions of mature specimens. The thickness of the diaphanotheca in the fifth to the tenth volution of the holotype measures 5, 6, 8, 12, 16, and 16 microns, respectively. The averages of the total thickness of the spirotheca in the first to the tenth volution of two specimens are 8, 8, 16, 20, 25, 22, 36, 40, 34, and 36 microns, respectively.

The tunnel is well developed from the second volution to the latter part of the last volution, and its path is essentially straight. The tunnel angle in the third to the ninth volution of the holotype measures 11°, 17°, 18°, 20°, 22°, 25°, and 25°, respectively. High and broad chomata occur from the second or third volution to the last part of the outermost volution. The tunnel side of the chomata is steep, but the poleward slope is low. In fact, in the third to the eighth volutions of specimens of nine to ten volutions, the chomata extend completely to the poles.

Discussion.—In addition to the genotype, *Y. iniqua* Lee, only two species have been described previously that I would refer without question to the genus *Yangchienia*, *Y. compressa* (Ozawa) and *Y. tobleri* Thompson. *Y. haydeni* is more closely similar to *Y. tobleri* than to either of the other two species. It differs from *Y. tobleri* in that its chomata are more massive, its tunnel angle is slightly smaller, the shell of mature specimens is smaller, and its chambers are lower and therefore the shell is more tightly coiled. *Y. haydeni* differs from *Y. iniqua* Lee, the genotype, especially in that its poles are more extended, the lateral slopes are not so highly convex, its tunnel is narrower and therefore the tunnel angle is smaller, and apparently its asymmetrical early portion contains fewer volutions. *Y. compressa* (Ozawa) is more highly elongate and therefore has a smaller form ratio than *Y. haydeni*, and the chomata of the former species are less massive than those of *Y. haydeni*.

Occurrence.—The holotype and all paratypes were obtained from the Bamian limestone 7 miles from the Bamian road fork on the road to Kabul, or 7 kilometers westerly from the summit of Shibar Pass, approximately 34° 55′ north latitude, 68° 18′ east longitude (Greenwich).

Types.—Stanford Univ. Paleo. Type Coll. No. 7811 (holotype), Nos. 7812–7816 (figured paratypes).

Genus SCHWAGERINA Möller

SCHWAGERINA FURONI Thompson, n. sp.

Plate 23, figures 1–4; plate 24, figures 7–10

Fusulina sp. Furon, 1927, L'Hindou Kouch et le Kaboulistan, p. 64, pl. 3.

Shell large, inflated fusiform; with sharply-pointed poles, steep slightly concave lateral slopes, and straight axis of coiling. Mature specimens of six to seven volutions measure 6.3 to 8.5 mm. in length and 3.3 to 4.2 mm. in width, giving a form ratio of 1:1.9 to 1:2.1. The shell retains essentially the same shape throughout growth of the individual. The form ratio is about 1:2 for the first volution to maturity. However, the lateral slopes of the first three to four volutions are convex, but the lateral slopes of the outer volutions of mature specimens become slightly concave.

The proloculum is large and spherical in shape. Its outside diameter measures about 430 to 500 microns, averaging 477 microns for three specimens. The shell expands essentially uniformly up to about the fifth volution. In the holotype the chambers increase in height up to the fifth volution, but they decrease in height slightly from the fifth volution to maturity. In several other specimens, however, the chambers increase in height slightly from the fifth volution to maturity. The average heights of the chambers in the first to the seventh volution of three specimens are 108, 171, 242, 314, 342, 363, and 324 microns, respectively.

The septa are relatively thick. They are

distinctly pendant-shaped in cross section, but the lower margin of the septa are distinctly thicker immediately over the tunnel than poleward from the tunnel. Although the anterior thin dark layer of the septa seems to be continuous with the tectum of the spirotheca, the posterior wedge-shaped layer occurs between the alveoli of the keriotheca of the spirotheca and the anterior thin dark layer of the septa. The septa are narrowly fluted throughout the length of the shell. Poorly developed cuneculi occur at the base of the septa, as in species of the genus *Parafusulina*. However, further than the presence of these poorly developed cuneculi, this species has little resemblance to the genotype of *Parafusulina*, *P. wordensis* Dunbar and Skinner. The average septal counts of the first to the seventh volution of two specimens are 12, 18, 27, 32, 34, 30, and 30, respectively.

The spirotheca is thick and is composed of a tectum and keriotheca with coarse alveoli. In fact, the keriotheca has coarse alveoli in the first part of the first volution. Secondary deposits continuous with the chomata and axial fillings cover the upper surfaces of the spirotheca in most parts of the inner volutions, but thin sections of numerous specimens indicate that the porous structure of the keriotheca completely penetrates the spirotheca in the outer volutions. The average thicknesses of the spirotheca in the first to the seventh volution of four specimens measure about 50, 70, 90, 110, 150, 150, and 150 microns, respectively.

The tunnel is low and of medium width, and its path is straight. The average tunnel angles of the second to the sixth volutions of two specimens measure 20°, 20°, 22°, 24°, and 30°, respectively. Discontinuous irregular chomata border the tunnel in the second volution to the beginning part of the last volution. Dense calcite essentially fills the chambers in the polar regions of the second to the next to outermost volution.

TABLE OF MEASUREMENTS (in millimeters) OF SCHWAGERINA FURONI

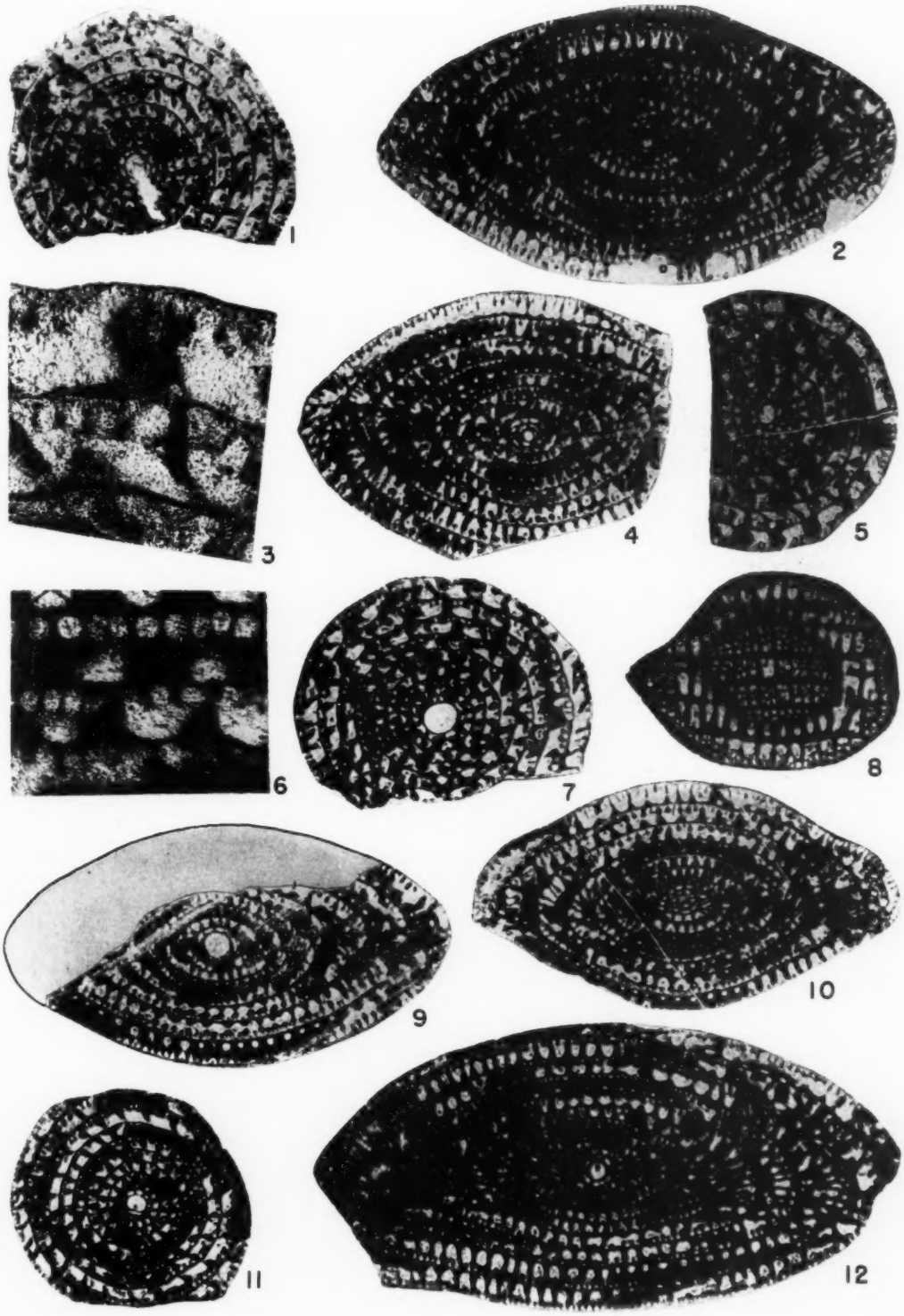
Specimen	L.	W.	Ratio	No. of volutions	Diam. of prol.	Height of volutions 1	2	3	4	5	6	7
1	8.55	4.16	2.0	7	.432	.118	.170	.225	.336	.360	.342	.324
2	6.33	3.72	1.7	6½	.504	.100	.200	.250	.300	.324	.370	—
3	—	3.33	—	6	.468	.108	.144	.252	.306	.342	.378	—

	Form ratio of volutions 1	2	3	4	5	6	7	Thickness of spirotheca 0	1	2	3	4	5	6	7
1	2.0	1.9	2.0	2.0	2.0	2.1	2.1	.040	.065	.081	.117	.121	.145	.181	—
2	2.2	2.1	2.0	1.9	1.8	1.9	—	.040	.061	.081	.093	.120	.155	.135	—
3	—	—	—	—	—	—	—	.044	.040	.061	.085	.101	.125	.121	—
4	—	—	—	—	—	—	—	—	.040	.061	.069	.101	.161	.161	.150

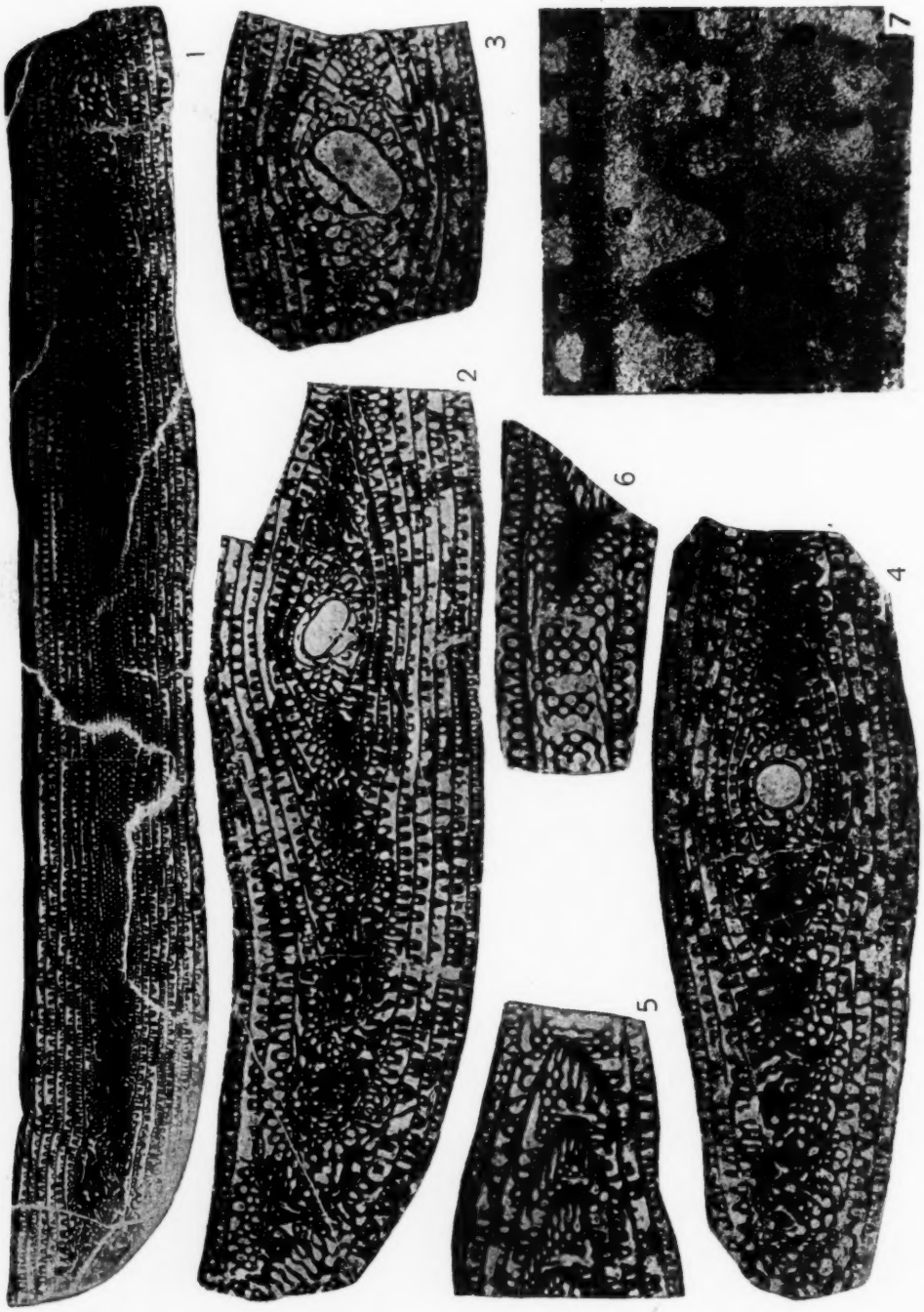
	Septal count 1	2	3	4	5	6	7	Tunnel angle (degrees) 1	2	3	4	5	6
1	—	—	—	—	—	—	—	—	20	20	21	23	32
2	—	—	—	—	—	—	—	—	21	—	22	25	28
3	10	19	27	39	40	33	—	—	—	—	—	—	—
4	13	18	26	25	27	27	30	—	—	—	—	—	—

EXPLANATION OF PLATE 25

FIGS. *1–12*—*Afghanella schencki* Thompson, n. sp. *1*, *5*, *7*, *11*, Sagittal sections of paratypes, ×20; *2*, axial section of the holotype, ×20; *3*, enlarged portion of a sagittal section of a paratype that shows the structure of the spirotheca, septa, and axial septula, ×100; *4*, *9*, *10*, *12*, axial sections of paratypes, ×20; *6*, enlarged portion of an axial section of a paratype that shows the structure of the primary and secondary septula, ×100. Bamian limestone, Afghanistan. (p. 153)



Thompson—Afghan Fusulinids



Thompson—Afghan Fusulinids

Discussion.—It is of more than ordinary interest that Hayden illustrated several highly enlarged photographs of the spirotheca of Afghan specimens of a species of *Schwagerina* that illustrated for the first time the porous nature of the spirotheca of the fusulinids. Hayden's discovery was not fully appreciated by other workers for many years. White (1931) first pointed out that fusulinids do not have a single aperture and also published photographs to illustrate the porous nature of both the antetheca and the spirotheca of some fusulinids. Thompson (1936) illustrated thin sections of *Schwagerina rutschi* Thompson from Sumatra that seemed to demonstrate that the alveoli extend completely through the spirotheca as minute pores. Dunbar and Skinner (1937) and others have added an abundance of evidence to demonstrate the spirotheca of the fusulinids is in reality porous, and that the alveoli of the keriotheca of the schwagerinids extend to the top of the spirotheca. However, the upper surfaces of the spirotheca in the inner volutions of most fusulinids are partly or completely covered by secondary deposits such as chomata, parachomata, axial fillings, and tectoria. Therefore, in the inner volutions of most fusulinids the fine pores of the spirotheca have been sealed over by later deposits.

S. furoni is similar in several features to *S. crassa* Deprat. However, the thicker spirotheca, larger proloculum, the lighter axial fillings of *S. furoni* serve to distinguish it from *S. crassa*. The specimens described and illustrated by Hayden as *Fusulina uralica* Krotow from north of Bamian are shorter, more rapidly expanding, and apparently do not have axial fillings.

A large group of fusulinid species that have been referred to *Schwagerina* occurs in rocks of the Tethys Sea zone of *Verbeekina-Neoschwagerina* and the zone of *Yabeina*. Most all of these species have axial fillings developed to a greater or lesser degree. In most of these the proloculum is large and the keriotheca is thick with coarse alveoli. Also, in many of them irregular small cuneculi have been observed. Although this latter feature is well developed in typical species of *Parafusulina* and *Polydiexodina*, these Tethys Sea species referred to *Schwagerina* bear few other points of resemblance to the type species of these genera. Although I would prefer for the present to continue the use of the generic term *Schwagerina* for these Tethys Sea species, it is doubtful that they are congeneric with the genotype of *Schwagerina*, *S. princeps* (Ehrenberg).

Occurrence.—The holotype and all paratypes were obtained from the Bamian limestone 7 miles from the Bamian road fork on the road to Kabul, or 7 kilometers westerly from the summit of Shibar Pass, approximately 34°55′ north latitude, 68°18′ east longitude (Greenwich).

Types.—Stanford Univ. Paleo. Type Coll. No. 7817 (holotype), Nos. 7818–7823 (figured paratypes).

Genus POLYDIEXODINA Dunbar and Skinner

The genus *Polydiexodina* was established by Dunbar and Skinner in 1931, and *P. capitanensis* Dunbar and Skinner from the Capitan limestone (upper Guadalupian series) was designated as the genotype. At the same time, they described *P. shumardi* Dunbar and Skinner from the upper part of the Guadalupian of Texas. Since 1931 only one or possibly two species of *Polydiexodina* have been described from America, *P.? rotundata* Dunbar and Skinner from the Guadalupian in Texas and *P. mexicana* Dunbar from the Guadalupian of Las Dilicias, Mexico.

Kahler (1933) was the first to recognize representatives of *Polydiexodina* from the Eastern Hemisphere. He described *Polydiexodina persica* Kahler from the Permian

EXPLANATION OF PLATE 26

All illustrations on this plate are unretouched photographs.

FIGS. *1*—*Polydiexodina afghanensis?* Thompson, n. sp. Tangenital section of an unusually large specimen associated with the holotype, that is referred with question to this species, ×5. Bamian limestone, Afghanistan. (p. 150)

2–7—*Polydiexodina afghanensis* Thompson, n. sp. *2*, Axial section of the holotypes, ×10; *3*, *4*, axial sections of paratypes, ×10; *5*, *6*, tangential sections of paratypes that show numerous auxiliary tunnels, ×10; and *7*, enlarged portion of an axial section of a paratype that shows the porous nature of the spirotheca, ×100. Bamian limestone, Afghanistan. (p. 150)

limestone of Darreh-Duzdan, Persia (Iran). In 1939 Doutkevitch (*in* Licharew, 1939) described *Polydiexodina darwasica* Doutkèvitch from the Darwas series of Darwas.

Several earlier reports included illustrations of fusulinids from widely separated areas in the Eastern Hemisphere that strongly suggest *Polydiexodina* is widely distributed geographically in that part of the world. Staff (1912) illustrated a sagittal section from Asia Minor (eastern Chaidar) as *Fusulina extensa* Schellwien that strongly suggests it has supplementary tunnels and is therefore referable to the genus *Polydiexodina*. Ozawa and Tobler (1929) briefly described and illustrated as "*Fusulina* cf. *elongata* Shumard" a form from the Aegean Islands of Greece (Katakupho) associated with a typical lower Tethys Sea fusulinid fauna. Their illustrations strongly suggest that form has supplementary tunnels and is referable to *Polydiexodina*. Diener (1911) illustrated a form as *Fusulina elongata* Shumard from Burma, and his illustrations demonstrate that *Polydiexodina* is present in that region. Newton (1926) described and illustrated as *Fusulina* cf. *granum-avenae* Roemer rather poorly preserved specimens of a large species from the Burma-Siam border that may also be referable to the genus *Polydiexodina*. This form is associated with poorly preserved specimens referred by Newton to *Doliolina* cf. *lepida* Schwager. Chaput (1932) listed "*Fusulina elongata*" from near Ankara (Angora) and Bursa, Turkey. Although his specimens were not described or illustrated, it is possible Chaput was studying a species of *Polydiexodina*.

POLYDIEXODINA AFGHANENSIS Thompson, n. sp.

Plate 24, figures 1–6; plate 26, figures 1–7

(?) *Fusulina elongata* Hayden, 1909, Geol. Survey India, Records, vol. 28, pp. 247, 248, pl. 17, figs. 3–5; pl. 20, figs. 1–12—(?) Furon, 1927, L'Hondou-Kouch et le Kaboulistan, p. 67.

TABLE OF MEASUREMENTS (in millimeters) OF POLYDIEXODINA AFGHANENSIS

Specimen	L.	W.	Ratio	No. of volutions	Diam. of prol.	Height of volutions 1	2	3	4	5	6	7	8	9	10
1	—	5.1	—	8	.660– .907	.116	.150	.150	.166	.166	.233	.200	.266	—	—
2	38.0+	5.0	7.6	10+	—	—	—	—	—	—	—	—	—	—	—
3	14.5	4.16	3.5	10	.738–1.080	.198	.180	.180	.162	.180	.180	.216	.180	.180	—
4	—	3.66	—	7½	.833–1.998	.180	.162	.180	.144	.144	.180	.126	.216	—	—
5	—	—	—	—	.610– .832	—	—	—	—	—	—	—	—	—	—
6	—	3.33	—	7	.721– .943	.126	.144	.180	.175	.180	.216	.252	—	—	—
7	14.43	3.22	4.5	10	.555– .777	.198	.162	.144	.144	.144	.162	.198	.180	.252	.216
8	21.0	4.0	5.2	10	.470– .888	.144	.126	.162	.144	.144	.162	.162	.198	.180	.216
9	15.54	3.66	4.2	9½	.720	.144	.108	.126	.162	.162	.162	.180	.216	.216	—

	Form ratio of volutions 1	2	3	4	6	7	8	9	10	Thickness of spirotheca 0	1	2	4	5	7	8	9	10
1	—	—	—	—	—	—	—	—	—	.036	.033	.036	.041	.050	.055	.062	—	—
3	1.5	1.7	2.2	2.6	3.4	3.8	—	—	—	.032	.024	.028	.028	.028	.040	.044	—	—
4	1.5	2.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	.028	.028	.024	.032	.028	.032	—	—	—
7	1.4	1.5	2.0	2.7	3.6	4.2	4.1	4.0	3.9	.032	.032	.032	.028	.032	.036	.040	.054	.054
8	1.9	2.2	3.2	4.2	5.1	5.5	5.6	5.5	—	.032	.032	.036	.024	.036	.036	.040	.048	.056
9	1.3	2.0	2.6	3.0	4.0	4.4	4.5	—	—	.032	.024	.028	.028	.028	.036	.028	.040	—

	Septal count 1	2	3	4	5	6	7	8
1	17	21	30	37	39	40	46	46
5	12	19	29	36	38	—	—	—
6	10	22	30	34	39	—	—	—

Description.—Shell large, elongate cylindrical to subcylindrical; with irregular to broadly curving axis of coiling, straight, uneven to slightly concave lateral slopes, and bluntly pointed to broadly rounded poles. The central part of the shell in most specimens is slightly inflated, but the central one-half of the shell of many specimens is essentially cylindrical. The axis of coiling is so irregular in most specimens that it is difficult to obtain an axial section that is well centered throughout the length of the shell. One of my largest specimens of ten volutions, the holotype, measures about 21 mm. in length and 4 mm. in width, giving

a form ratio of 1:5.2. Three other specimens of nine and one-half to ten volutions measure 14.5 to 15.5 mm. in length and 3.2 to 4.2 mm. in width, giving form ratios of 1:4.5 to 1:3.5. One unusually large specimen (pl. 26, fig. 1) of more than ten volutions measures more than 38 mm. in length and about 5 mm. in width, giving a form ratio of less than 1:7.6. However, the thin section of this specimen is not centered and the proloculum was not observed. It is possible this specimen is a microspheric individual of this species. If it is not a microspheric individual, it undoubtedly is not conspecific with the holotype of this form. The first and second volutions of this species are irregular in shape, due partly to the irregular proloculum around which they are coiled. The third to the sixth volutions have sharply pointed poles and relatively steep but straight lateral slopes. The averages of the form ratios of the first to the ninth volutions of four specimens are 1:1.5, 1:1.9, 1:2.5, 1:3.1, 1:3.7, 1:4.0, 1:4.5, 1:4.7, and 1:4.7, respectively.

The spirotheca is thin. In most parts of the shell only the keriotheca is observable in the spirotheca. However, a thin dark layer, the tectum, is preserved in parts of the shell. The upper surface of the spirotheca apparently was partly destroyed during the development of the numerous secondary tunnels. Therefore, the thickness of the spirotheca changes within short distances laterally in the same volution. The averages of the thicknesses of the spirotheca in the first to the tenth volution of five specimens are 28, 30, 32, 28, 31, 34, 36, 38, 47, and 55 microns, respectively. The alveoli of the keriotheca are relatively coarse, and they change in width only slightly from the base to the top of the spirotheca. The coarse pores of the keriotheca extend completely through the spirotheca in many parts of the shell (*See* pl. 26, fig. 7), but it is most likely that the tectum has been removed from those areas during the development of the secondary tunnels. It is very unlikely that such coarse pores extended through the outermost wall during the life of the individual. This conclusion is further supported by the fact that the coarse alveoli pass completely through the spirotheca in only those parts of the shell where the secondary tunnels have been developed.

The proloculum is large and irregular in shape. The maximum outside diameter of the prolocula of eleven specimens measures 640 to 2000 microns and its minimum outside diameter measures 470 to 833 microns. For these same specimens the average maximum outside diameter is 1000 microns and the average minimum diameter is 677 microns. The shell is relatively tightly coiled. The heights of the volutions increase slowly and irregularly, and the average heights of the first to the tenth volution of seven specimens are 158, 147, 160, 159, 186, 185, 191, 209, 207, and 216 microns, respectively. The heights of the volutions are less immediately over the proloculum in the central part of the shell, and they increase in height slowly poleward from the center of the shell.

The septa are intensely fluted throughout the length of the shell and throughout all volutions. Cuneculi and therefore foramen are well developed throughout the length of the shell. The average septal counts of the first to the eighth volution of three specimens are 13, 21, 30, 36, 39, 40, 46, and 46, respectively.

This form does not have a distinct central tunnel. Multiple accessory tunnels are developed in all volutions except the latter part of the outermost volution. They are not easily recognized in axial thin sections, and the total number of such tunnels in any one volution has not been determined. However, at least 24 accessory tunnels occur in the penultimate volution of some mature specimens of eight to ten volutions. Axial fillings occur in the extreme polar regions throughout the shell from the third volution to the penultimate volution.

Polydiexodina afghanensis is more closely similar to *P. persica* Kahler from Darreh-Duzden, Iran (Persia), than any previously described form. Neither of these species has a well developed central or sagittal tunnel. However, the proloculum of *P. persica* is smaller, the shell expands more slowly and therefore the shell is smaller for corresponding volutions, and the secondary tunnels are wider and less numerous than in *P. afghanensis*.

The fusulinid from Kehsi Mansam, Burma, discussed and illustrated by Diener (1911) as *Fusulina elongata* Shumard obviously is referable to the genus *Polydiexodina*. It is closely similar to *P. afghanensis*, but Diener's sections are not sufficiently well centered for detailed comparisons.

In addition to *P. persica* Kahler and *P. afghanensis*, n. sp., the only other proposed species of *Polydiexodina* from the Eastern Hemisphere, so far as I have been able to determine, is *P. darwasica* Doutkevitch from the Darwas series of Darwas. The latter species apparently is smaller in size and has a smaller proloculum than *P. afghanensis*. Other differences probably could be pointed out by direct comparison of specimens of these two forms.

Occurrence.—The holotype and all paratypes were obtained from the Bamian limestone 7 miles from the Bamian road fork on the road to Kabul, or 7 kilometers westerly from the summit of Shibar Pass, approximately 34°55′ north latitude, 68°18′ east longitude (Greenwich).

Types.—Stanford Univ. Paleo. Type Coll., No. 7824 (holotype), Nos. 7825–7833 (figured paratypes), No. 7834 (figured specimen).

Genus AFGHANELLA Thompson, n. gen.

Genotype: *Afghanella schencki* Thompson, n. sp.

The genus *Afghanella* is here being proposed for fusulinids that previously have been referred to the genus *Sumatrina* by some workers and to the genus *Neoschwagerina* by others. The genotype is here designated as the species described below as *Afghanella schencki*, n. sp. Species of this new genus have some features similar to those of the genotypes of both *Sumatrina* and *Neoschwagerina*. However, species of *Afghanella* possess so many internal structures not similar to those of the genotype species of either of these genera that it seems necessary to place them in a separate genus.

Generic diagnosis.—Shell small, inflated fusiform to ellipsoidal in shape; with straight axis of coiling, broadly convex lateral slopes, and rounded to bluntly pointed poles. Mature specimens contain at least ten to thirteen volutions. Mature specimens of the genotype contain nine to eleven volutions and measure about 1.8 to 2.0 mm. in width and 3.4 to 4.2 mm. in length. The volutions are essentially symmetrical throughout growth of the individual. The proloculum is spherical in shape.

The spirotheca is thin and is composed of a dense upper layer and a thin lower layer with fine alveoli-like structures. The thickness of the spirotheca in the genotype is about 16 microns in the ninth volution. The spirotheca of *A. sumatrinaeformis* (Gubler) is about 9 to 18 microns thick. In most parts of the shell the spirotheca appears to be composed of a thin upper dense structureless layer and an underlying thin structureless layer of less dense material.

The septal structure is composed of the primary axial septa, primary transverse septula, secondary transverse septula, and axial septula. The primary transverse septula occur throughout the shell. They reach the top of the parachomata completely across the chambers except for small lateral openings near the centers of the chambers. The lower part of the septula is pendant-shaped in cross section, but the uppermost part of the septula is exceedingly thin and is attached to the lower surface of the spirotheca. Dense calcite, apparently continuous with the parachomata, covers the lower part of the septula.

Secondary transverse septula occur between adjacent transverse septula from the fourth or fifth volution to maturity. However, only one secondary septula occurs between adjacent primary transverse septula in the fourth to eighth volution. Beyond the eighth volution two secondary septula occur between adjacent primary septula. All of the secondary septula in the inner volutions are of essentially uniform length, pendant-shaped in cross section, and exceedingly thin at the top where they are attached to the lower surface of the spirotheca.

Axial septula first appear near the end of the third volution. However, only one occurs between the septa in the fourth to eighth volution. Beyond the seventh volution two septula occur between the septa, and the number increases to four in the outer volutions of mature specimens. The

axial septula in the fourth and fifth volutions are short downward deflections of the lower surface of the spirotheca. Beyond the fifth volution, the axial septula become pendant-shaped in cross section, essentially uniform in length, and exceedingly thin at their upper margins.

Foramen are abundant throughout the shell. Parachomata occur between the foramen throughout the shell. The parachomata are joined by the lower edge of the primary transverse septula throughout most of the width of the chambers of all volutions except the last.

Remarks.—The pendant-like cross section of the secondary septula of this genus is similar to that of the septula of the genus *Sumatrina*. Also, the exceedingly thin upper margins of all of the septula are like those of *Sumatrina*. However, throughout the shells of species of *Sumatrina* multiple axial septula occur between the primary septa and multiple secondary septula occur between the primary transverse septula. Also, the secondary transverse septula of *Sumatrina* remain of essentially the same length throughout the shell. Furthermore, the shape of shells of species of *Sumatrina* is different from the shape of the shell of species of *Afghanella*.

Although the general shape of the shell of *Afghanella* is closely similar to that of *Neoschwagerina* Yabe, the spirothecal structure, the secondary septula arrangement and general structure are markedly different.

Species of *Afghanella* can be distinguished from those of *Yabeina* Deprat, *Colania* Lee, and *Lepidolina* Lee by the fact that their secondary septula are pendant-shaped in cross section, very thin in their upper margins, absent in the early volutions of the shell, essentially uniform in shape in most parts of the shell, and generally less numerous in corresponding volutions.

The evolutionary position of *Afghanella* in the biological development of the neoschwagerinids is uncertain. Data concerning a larger number of species of the genus with definite stratigraphic information will be necessary before the evolution within the genus can be determined. It now seems probable that some of the more highly developed genera of the neoschwagerinids, such as *Yabeina*, *Colania*, and *Lepidolina*, may have evolved from *Afghanella* rather than directly from *Neoschwagerina*.

Age.—Species of *Afghanella* are known from only three localities, Pong Lao (Laos), French Indo-China [*A. sumatrinaeformis* (Gubler)], Greece [*A. pesuliensis* (Ozawa and Tobler)], and Afghanistan [*A. schencki*, n. sp., the genotype]. At all three localities they are associated with fuslinids of the Zone of *Verbeekina-Neoschwagerina*.

AFGHANELLA SCHENCKI Thompson, n. sp.
Plate 25, figures 1–12

Neoschwagerina annae Hayden, 1909, Geol. Survey India, Records, vol. 38, pp. 250, 251, pl. 22, figs. 8–14.

N. (*Sumatrina*) *annae* Furon, 1927, L'Hindou-Kouch et le Kaboulistan, p. 64, pl. 3.

N. sumatrinaeformis Gubler (part), 1935, Soc. géol. France, Mém., n. s., tome 11, mém. 26, p. 153.

Shell minute, inflated ellipsoidal to fusiform in shape; with straight axis of coiling and convex lateral slopes. Mature specimens of nine to eleven volutions measure 1.8 to 2.2 mm. in width and 3.4 to 4.2 mm. in length, giving a form ratio of 1:1.7 to 1:2.1. The shape of the shell remains essentially the same from the sixth volution to maturity. However, the shape of the shell changes from essentially spherical in the first volution to ellipsoidal in the sixth volution. The form ratios of the first to the eleventh volution in the holotype are 1:1.3, 1:1.7, 1:1.7, 1:1.8, 1:1.8, 1:1.9, 1:2.0, 1:2.2, 1:2.2, 1:2.1, and 1:2.0, respectively.

The proloculum is spherical in shape, and its outside diameter measures 90 to 250 microns. The average outside diameter of the proloculum for seven specimens is 146 microns. One specimen that may be referable to this species has a proloculum of 378 microns. The shell expands in size uniformly. The average heights of the first to the tenth volution of six specimens are 44, 48, 67, 80, 95, 100, 114, 127, 150, and 157 microns, respectively.

The spirotheca is thin and is composed of a thin dense upper layer and a thin lower layer of less dense material. Although the lower layer of the spirotheca appears structureless in most of the thin sections, fine alveoli-like structures can be seen in the outer volutions of several specimens, including the holotype. The tectum and lower

layer of the spirotheca measure about 16 microns in thickness in the eighth volution of the holotype. However, in the sixth to the eighth volution the combined thickness of these layers is only about 8 microns. Dense calcite covers the upper surface of the spirotheca, that obviously is continuous with the parachomata.

The septal structure is composed of the septa, primary transverse septula, secondary transverse septula, and axial septula. The septa are composed of the downward deflection of the upper layer of the spirotheca. They are thickly coated with dense calcite that apparently is continuous with the deposits of the parachomata. The average septal counts of the first to the ninth volutions of four specimens are 9, 14, 18, 19, 21, 24, 26, 27, and 26, respectively. The septa are unfluted and they extend slightly anteriorly as they reach the base of volution.

The primary transverse septula extend down from the base of the spirotheca. They are in contact with the top of the parachomata almost completely across the chambers so as to form walls. The upper parts of the primary septula are exceedingly thin, but they are covered in their lower areas by thick deposits of dense calcite. However, in the anterior area of the chambers, the parachomata are slightly below the base of the primary transverse septula, resulting in small lateral openings. One secondary transverse septula is introduced between each pair of adjacent primary transverse septula in the fourth to fifth volutions. Therefore, outward from the fifth to sixth volution, at least one secondary transverse septula alternates in position with the primary transverse septula. Beyond the eighth to ninth volution, two secondary transverse septula occur between some adjacent primary transverse septula. The upper parts of the secondary transverse septula are very thin and hang from the lower surfaces of the spirotheca. The secondary transverse septula are short, pendant-shaped, and essentially uniform in length in the inner seven to eight volutions. In the outer volution of mature specimens the secondary transverse septula are not distinctly pendant-shaped and they are not of uniform length.

A single axial septula first appears between the primary septa near the end of the third volution. The first to appear are short downward deflections of the lower surface of the spirotheca. Near the end of the fifth volution they become pendant-shaped. Two pendant-shaped axial septula occur between adjacent septa near the end of the seventh volution, and the number gradually in-

TABLE OF MEASUREMENTS (in millimeters) OF AFGHANELLA SCHENCKI

Specimen	L.	W.	Ratio	No. of volutions	Diam. of prol.	Height of volutions 1	2	3	4	5	6	7	8	9	10
1	4.23	1.98	2.1	10	.165	.044	.052	.064	.081	.089	.093	.113	.125	.162	.162
2	3.78	2.07	1.8	11	.097	.036	.036	.044	.057	.081	.101	.115	.101	.150	.174
3	—	—	—	—	.198	—	—	—	—	—	—	—	—	—	—
5	—	1.98	—	9	.167	.048	.053	.073	.077	.089	.109	.125	.121	.145	—
6	—	2.16	—	9	—	.040	.065	.105	.093	.133	.121	.133	.141	—	—
7	—	1.8	—	9	.162	.040	.036	.061	.081	.088	.081	.097	.129	.129	.121
8	3.42	1.98	1.7	9¼	.090	.054	.049	.057	.089	.089	.097	.109	.133	.162	.170
9	—	1.98	—	9	—	—	—	—	—	—	—	—	—	—	—

	Form ratio of volutions 1	2	3	4	5	6	7	8	9	10	11	Number of foramen 5	6	7	8	9	10	11
1	—	—	—	—	—	—	—	—	—	—	—	—	25	21	27	31	32	—
2	1.3	1.7	1.7	1.8	1.8	1.9	2.0	2.2	2.2	2.1	2.0	14	16	20	24	28	34	39
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	23	—	—	—
8	1.1	1.2	1.4	1.6	1.5	1.5	1.5	1.4	1.5	—	—	—	18	20	24	28	34	—

	Septal count 1	2	3	4	5	6	7	8	9
5	7	13	17	20	20	21	26	26	26
6	11	16	19	21	21	23	26	26	30
7	7	12	16	18	19	24	26	24	24
9	10	14	19	19	22	26	26	32	24

creases to four in the outer volutions of mature specimens.

Elliptical foramen occur at the base of the septa throughout the shell. The averages of the foramen in the fifth to tenth volutions of three specimens, including the holotype, are 14, 20, 20, 24, 29, and 33, respectively. Broadly rounded parachomata occur between the foramen. The parachomata are high and narrow adjacent to the septa where they are in contact with the pendant-like lower edge of the primary transverse septula.

Discussion.—This species is closely similar to *A. sumatrinaeformis* (Gubler) from French Indo-China. In fact, Gubler expressed the belief the specimens illustrated by Hayden were conspecific with the type specimens of *A. sumatrinaeformis*. The holotype and paratypes of *A. schencki* are closely similar to Gubler's type specimens of *A. sumatrinaeformis* and they may represent varieties of the same species. However, the Afghan species I am studying is smaller in size for corresponding volutions and more highly elongate in shape with more nearly pointed poles than *A. sumatrinaeformis*.

A. schencki closely resembles *A. pesuliensis* (Ozawa and Tobler) from the Ægean Islands of Greece. Although measurements were not given for the type specimens of *A. pesuliensis*, the original illustrations indicate that this form is larger at maturity, has more sharply pointed poles, more highly concave lateral slopes, and larger proloculum than *A. schencki*. It is of interest to note *A. pesuliensis* is associated with species of the genera *Yangchienia* Lee, probably *Polydiexodina*, *Verbeekina*, and *Neoschwagerina*.

Sumatrina annae Volz, to which Hayden referred this species, is more highly elongated and less highly inflated, the nature and arrangement of the septula are markedly different, and the spirotheca apparently has a structure different from the type specimens of *A. schencki*.

Occurrence.—This species is abundant in the samples from the Bamian limestone 7 miles from the Bamian road fork on the road to Kabul, or 7 kilometers westerly from the summit of Shibar Pass approximately 34°55′ north latitude, 68°18′ east longitude (Greenwich).

Types.—Stanford Univ. Paleo. Type Coll., No. 7835 (holotype), Nos. 7836–7844 (figured paratypes).

Genus NEOSCHWAGERINA Yabe
NEOSCHWAGERINA CRATICULIFERA HAYDENI Doutkevitch and Khabakov
Plate 23, figures 12, 13

Neoschwagerina craticulifera Hayden, 1909, Geol. Survey India, Records, vol. 38, pp. 248, 249, pl. 21, figs. 1–7.—Furon, 1927, L'Hindou-Kouch et le Kaboulistan, p. 64, pl. 3.—Gubler, 1935, Soc. géol. France, Mém., n. s., tome 11, mém. 26, p. 153.

Neoschwagerina craticulifera var. *haydeni* Doutkevitch and Khabakov, 1934, Acad. Sci. USSR, vol. 8, pp. 94–99, pl. 2, figs. 6–8; pl. 3, figs. 1, 2.

I have obtained only one well-oriented axial section of this species. I cannot draw up a complete specific description based on this single specimen and am therefore not able to make detailed specific comparisons with Doutkevitch and Khabakov's specimens from Pamir or with other congeneric specimens from other localities. However, for the sake of completeness, I have drawn up the following description based on this single specimen:

Shell of medium size, inflated ellipsoidal in shape; with straight axis of coiling and broadly convex lateral slopes. The axial section contains thirteen and one-half volutions and measures 4.5 mm. in length and 3.2 mm. in width. The form ratios of the first to the thirteenth volution are 1:0.9, 1:1.3, 1:1.3, 1:1.3, 1:1.4, 1:1.5, 1:1.4, 1:1.5, 1:1.5, 1:1.4, 1:1.5, 1:1.4, and 1:1.4, respectively. As is obvious, the shell is essentially of the same shape from the fourth volution to maturity.

The proloculum is minute and its outside diameter measures about 93 microns. The heights of the first to the thirteenth volution measure 32, 40, 48, 65, 73, 109, 121, 133, 133, 170, 170, 161, and 190 microns, respectively.

The spirotheca is thick and is composed of a tectum and thick lower layer with a fine alveoli-like structure. The thicknesses of the spirotheca midway between the septula in the third to the thirteenth volution measure 16, 16, 20, 28, 28, 40, 49, 49, 44, 40, and 40 microns, respectively. Transverse septula occur throughout the shell. They obviously are the downward extension of the

porous layer of the spirotheca. The porous structure of the spirotheca extends in fan-shaped fashion to the junction of the septula with the parachomata. Parachomata are developed throughout the shell. They are relatively low and extend up to the base of the septula completely across the chambers, except near the center of the chamber. The foramen are low and elliptical in cross section. There are 5, 8, 11, 16, 16, 19, 20, 22, 25, 27, and 31 foramen in the fourth to the fourteenth volutions, respectively.

Remarks.—Furon illustrated numerous thin sections of specimens of this species from his Locality 2, westerly from Shibar Pass, presumably near the same locality from which the collection I am studying was obtained. Furon's illustrated thin section shows this species is associated with species of *Verbeekina*, *Afghanella*, and *Schwagerina*. The collection I am studying demonstrates it is also associated with *Polydiexodina afghanensis*, n. sp., *Yangchienia haydeni*, n. sp., and *Afghanella schencki*, n. sp.

Occurrence.—This form is rare in the sample I have from the Bamian limestone 7 miles from the Bamian road fork on the road to Kabul, or 7 kilometers westerly from the summit of Shibar Pass, approximately 34°55′ north latitude, 68°18′ east longitude (Greenwich).

Repository.—Stanford Univ. Paleo. Type Coll., No. 7845 (figured specimen).

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EARLY ORDOVICIAN CEPHALOPODS WITH SUBTERMINAL APERTURES

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ABSTRACT—Two types of coiled nautiloids with oblique subventral apertures are illustrated and described. Each represents a distinct genus, but both belong in the Tarphyceratidae. It is concluded that this sort of aperture was probably developed to facilitate crawling.

A new species of *Campbelloceras*, also from the Lower Ordovician of Missouri, is described in an appendix.

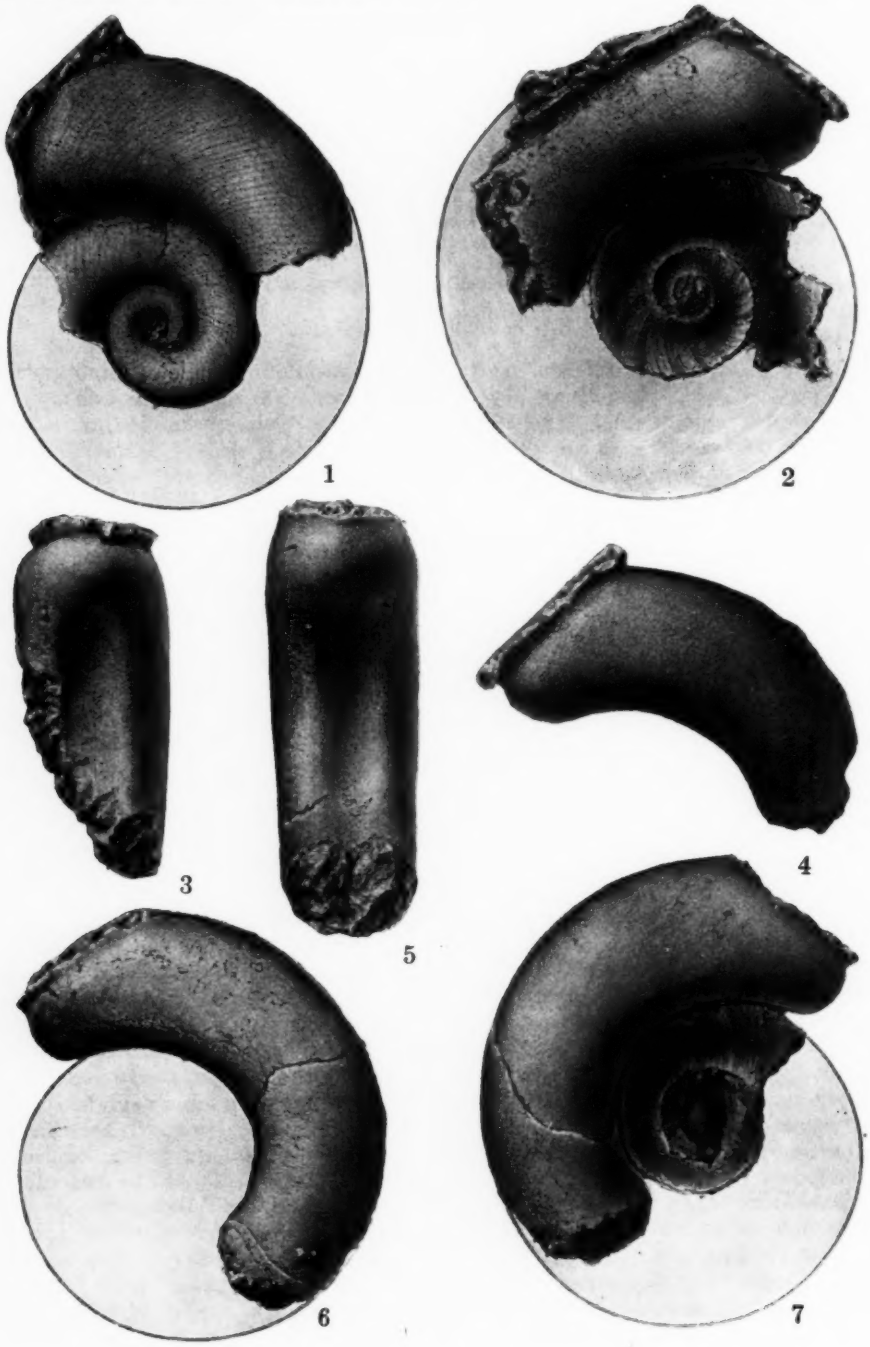
THE GREAT majority of nautiloid cephalopods known from the Lower Ordovician are rather poorly preserved and incomplete. Presumably, their shells, like those of their modern relatives, were composed largely of aragonite and therefore were not as readily fossilized as were contemporaneous brachiopods, with calcite and corneous shells, and trilobites, with chitinous tests. As might be expected, phragmacones, that is, the chambered portions of cephalopod shells, are much more abundant as fossils than living chambers, and in general they show less evidence of crushing and distortion during preservation. This fact is of course largely a result of the support contributed to the shell by the septa; but, in addition, the living chamber is relatively large and, because of its salient position, particularly in coiled forms, it would be the first part of the shell to be broken. Furthermore, in many of the Early Paleozoic coiled cephalopods, at full maturity the living chamber was not in contact with the preceding volution and therefore it was particularly vulnerable.

As a result of these facts, it is rather rare to find early cephalopods in which the apertural margins are intact, and the discovery of some fairly complete internal molds of nautiloid living chambers in the Lower Ordovician of Missouri seems to merit special consideration. The importance of this find is greatly increased by the peculiarity of the aperture in these specimens. It is subterminal (that is, subventral) in position and is strongly oblique to the long axis of the conch, sloping in an adoral direction from the venter and not reaching the dorsum.

As a general rule the shape of the nautiloid aperture throughout ontogenetic development is revealed by the growth lines. In many cases the aperture is marked ventrally by a notch or reentrant, the hyponomic sinus, through which the ambulatory funnel or hyponome protruded. This sinus is especially useful in orienting straight or slightly curved shells, as it is always ventral in position. In modern *Nautilus* the aperture bears a broad, shallow, broadly rounded hyponomic sinus and two small lateral sinuses. The latter are on a line with the eyes and enable the animal to see without protruding much of the anterior portion of its body from the conch. Sinuses in the apertural margins are, to be sure, separated by forward-projecting crests, and the dorsal side of the aperture is in many cases occupied by a crest known as the dorsal crest. In some genera the lateral zones of the aperture are straight and directly transverse; in others they are produced as crests or lappets.

Nautiloids with contracted apertures were common during the Early and Middle Paleozoic, though rare thereafter. As was pointed out by Hyatt in 1900, the closure of the aperture is never complete. It may take place through the inward growth of the lateral margins as in *Phragmoceras*, resulting in a dorsoventral slit; or from the dorsal and lateral margins forming a spoon-shaped or T-shaped aperture as in *Gomphoceras* and *Mandaloceras;* or, as in *Acleistoceras* and *Hercoceras*, it may occur principally from the dorsum and the venter, resulting in a transverse opening. Forms with very small apertural openings must have been microphagous, or essentially so.

Once the aperture had become strongly



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contracted, forward growth was almost certainly impossible. Presumably, therefore, throughout adolescence the aperture was wide open even in those forms that had greatly restricted apertures during later growth stages. The development of a contracted aperture may therefore be taken as evidence of full maturity.

It seems fairly certain that specializations of this type were developed so that the animal would be better adapted to its environment, and they are not a response to senility. A wide open aperture would of course permit the animal to crawl as well as to swim by means of the hyponome, whereas a strongly contracted aperture would probably prohibit the former method of locomotion. Furthermore, forms with greatly restricted apertures could not have protruded the head and tentacles and thereby increased their buoyancy, though possibly they could have contracted their bodies to decrease the amount of water displaced. These facts seem to suggest that during early ontogenetic development, these animals were chiefly benthonic, but that at full maturity they were largely, if not entirely, nektonic.

It should be noted in this connection that the ontogenetic development of the color markings on the shells of representatives of *Nautilus* indicates that they, also, are benthonic during early adolescence, but not at maturity. That is, the light ventral zone of *Nautilus*, characteristic of nektonic animals, is developed only as maturity is attained. Unfortunately, very little is known about the life history of these modern remnants of a once great group of marine invertebrates. Their tentacles bear no suckers, but the tentacular surfaces are transversely ridged, which presumably enables them to adhere to rough objects. It is stated that in their normal habitat in the South Pacific they are generally found hovering not far above or coming to rest on the sea floor, but that their tentacles are rarely used for crawling as the animals move almost entirely by swimming. Since the aperture of modern nautiloids is more or less normal to the long axis of the conch, it is probably none too convenient for them to crawl on their tentacles. The oblique subterminal apertures of the two Lower Ordovician species described in this paper would, however, seem to be well adapted to a crawling habit, and that may well have been the impelling motive behind their development. Furthermore, the shape and position of the aperture in these forms would certainly not prohibit swimming by means of a hyponome, and the opening was large enough to permit the cephalopodium portion of the animal's body to be protruded from the shell to increase the buoyancy. The extension of the shell that was secreted over the dorsal zone of the aperture may have served in a small way the same purpose as does the hood of modern *Nautilus*.

Growth lines are preserved on only one of the forms under consideration. They suggest that the aperture became strongly oblique only after the conch was approaching maturity, and almost certainly the dorsal zone of the aperture did not become restricted until full maturity was attained and forward growth ceased.

The photographs which accompany this study were retouched by Mr. Howard Webster and Miss Mary G. Allen, both of Iowa City. Acknowledgment is also due to the Graduate College of the State University of Iowa, which made the preparation of this report financially possible.

EXPLANATION OF PLATE 27

FIGS. *1–7*—*Moreauoceras milleri* Cullison. Figures *1–4* represent the holotype, and *5–7* the paratype. Figure *1* is an artificial cast. Figure *2* shows the internal mold of part of the outer volution and the external mold of the inner volutions. Figures *3* and *4* are dorsal and lateral views of the adoral portion of figure *2*. Figures *5* and *6* are dorsal and lateral views of the adoral portion of figure 7. Figure *7* shows the internal mold of part of the outer volution and the external mold of the penultimate volution. All illustrations are ×3. Both specimens are from the Rich Fountain formation near Moreau River in Cole County, Missouri. (p. 160)

SYSTEMATIC PALEONTOLOGY

Genus MOREAUOCERAS Cullison, 1944
Genotype: *Moreauoceras milleri* Cullison

Conch small, nautiliconic, subdiscoidal, and moderately expanded orad. It consists of a few volutions that are subcircular in cross section but are distinctly impressed dorsally. Umbilical perforation small. Living chamber about half a volution in length. Surface of test marked only by somewhat fasciculate growth lines. At full maturity aperture is oblique and subterminal, sloping orad from the venter and being restricted dorsally. Sutures form slight lateral and dorsal lobes. Siphuncle small, orthochoanitic in structure, and ventral and marginal in position.

Clearly this genus is related to *Campbelloceras* Ulrich and Foerste and *Pilotoceras* Cullison. It can be differentiated from the former by means of its sutures and presumably also by its peculiar aperture; nevertheless, it will be difficult indeed to distinguish immature representatives of these two genera, and some of the forms now referred to *Campbelloceras* may be found to belong in the genus under consideration. In *Pilotoceras* the whorls are cordate in cross section. All three of these genera belong in the Tarphyceratidae as their conchs are nautiliconic and subdiscoidal, their whorls are impressed dorsally, their sutures are rather simple, and their siphuncles are orthochoanitic in structure and are located between the venter and the center of the conch.

The only known representative of this genus is *M. milleri* Cullison of the Lower Ordovician of central Missouri. The genus was named for Moreau River, near which the genotype was found.

MOREAUOCERAS MILLERI Cullison
Plate 27, figures 1–7

Moreauoceras milleri Cullison, 1944, Missouri Univ., School Mines and Metallurgy, Bull. tech. ser., vol. 15, no. 2, pp. 23, 68–69, pl. 32, figs. 13–19.

Both the holotype and the paratype of this species are available for study. When complete, each of them was about 20 mm. in diameter.

The conch consists of about two and one-half volutions which are in contact with each other throughout their entire length. The umbilicus appears to be perforate. The whorls are subcircular in cross section but are slightly impressed dorsally. Near the adoral end of complete mature specimens the conch is about 7 mm. high and about 7½ mm. wide, and the impressed zone is about ½ mm. deep.

The surface of the test bears numerous fine growth lines which are somewhat fasciculate. Except in the immediate vicinity of the aperture of fully mature specimens, the growth lines curve apicad from the umbilical seam and form a rounded ventral sinus. These growth lines indicate the shape of the aperture during ontogenetic development. However, after the conch reached full maturity the aperture became greatly modified; the dorsal and dorsolateral portions of the test rounded over the dorsal part of the aperture and the aperture thus became subterminal and ventrolateral in position. Then the walls of this constricted aperture appear to have become slightly flared.

The sutures are somewhat sinuous, forming broad, shallow, broadly rounded flexures. Each forms a ventral saddle, lateral lobes, dorsolateral saddles, and a dorsal lobe.

The siphuncle is ventral and marginal in position, is composed of cylindrical seg-

EXPLANATION OF PLATE 28

FIGS. *1–3—Campbelloceras tuelli* Miller and Cullison, n. sp. The holotype, from a residual chert boulder on the fourth member of the Roubidoux formation south of Fort Leonard Wood, Missouri, ×1. (p. 162)

4, 5—Pilotoceras brunei Cullison. The holotype, from the Rich Fountain formation at Pilot Knob, Phelps County, Missouri, ×3. (p. 161)

6–8—Campbelloceras simplex Cullison. The holotype, from the lower part of the Cotter dolomite south of Crystal City, Missouri, ×1. (p. 162)

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ments, and is rather small in size. Its diameter is equal to only about one-eighth that of the conch.

Remarks.—The type specimens of this species are preserved in white chert. Both of them consist of internal molds of the adapertural portions of the outer volution of the conch and external molds of much of the inner volutions.

Occurrence.—Both of the type specimens came from residual chert of the *Jeffersonia* trilobite zone about 30 feet above the School Mine ledge in the lower part of the Rich Fountain formation (Jefferson City group) at the base of the hill on the north side of Moreau River and on the east side of U. S. Highway 63 in the SW¼ SW¼ sec. 27, T. 44 N., R. 11 W., Cole County, Missouri.

Types.—Yale Peabody Museum, 17129 (holotype); and Missouri School of Mines and Metallurgy, 7225 (paratype).

Genus PILOTOCERAS Cullison, 1944
Genotype: *Pilotoceras brunei* Cullison

In this genus, the conch, which is nautiliconic (though slightly uncoiled at full maturity), is small as it consists of only a few volutions and is rather gradually expanded orad. It is sublenticular in shape as the whorls are cordate in cross section, compressed and flattened laterally, subangular ventrally, and slightly but distinctly impressed dorsally. The umbilical perforation is small. The living chamber is about two-fifths of a volution in length. The aperture at full maturity appears to be oblique and subterminal, sloping orad from the venter and being restricted dorsally. The sutures form shallow dorsal and lateral lobes. The siphuncle is small and is located between the center and the venter—almost certainly it is orthochoanitic in structure.

Though this genus should be referred to the Tarphyceratidae, it differs from all other members of that family in that its conch is subangular ventrally. Also, insofar as is now known, its aperture resembles only that of *Moreauoceras.* In general physiognomy *Pilotoceras* resembles *Shumardoceras* and *Wichitoceras;* however, in both of those genera the conch is not impressed dorsally, and in *Wichitoceras* the siphuncle is dorsal in position.

The only species that is being placed in this genus is *P. brunei* Cullison of the Lower Ordovician of south-central Missouri. The genus was named for Pilot Knob in Phelps County, where the genotype was found.

PILOTOCERAS BRUNEI Cullison
Plate 28, figures 4, 5

Pilotoceras brunei Cullison, 1944, Missouri Univ., School Mines and Metallurgy, Bull. tech. ser., vol. 15, no. 2, pp. 23, 68, pl. 32, figs. 5, 6.

The holotype, the only representative of this species known, is a fairly complete internal mold of a mature specimen, and it attains a maximum diameter of about 28 mm. The conch consists of about three whorls, which are in contact except in the extreme adoral portion of the living chamber. The umbilicus appears to be perforate. The living chamber is about two-fifths of a volution in length. The whorls are cordate in cross section as they are slightly impressed dorsally, compressed and flattened laterally, and subangular ventrally. The lateral zones of the conch, which converge ventrally, are almost flat but are very slightly concave. Near the adoral end of the holotype the conch is about 8 mm. high and about 5 mm. wide. The aperture of this specimen is none too well preserved, but it appears to resemble that of *Moreauoceras milleri* Cullison in all available particulars. That is, after the conch had reached full maturity the aperture became greatly modified; the dorsal and lateral portions of the test rounded over the dorsal part of the aperture and the aperture thus became subterminal and ventrolateral in position. Then the walls of this constricted aperture were slightly flared.

The sutures are slightly sinuous; each forms a ventral saddle, a broad shallow lateral lobe, an asymmetrical dorsolateral saddle, and a slight dorsal lobe. A structure that appears to represent the siphuncle is small in size and is located somewhat ventrad of the center of the conch.

Remarks.—The holotype of this species is preserved in white chert. Although portions of the apertural margins are covered with matrix, the general nature of the aperture can be ascertained with a fair degree of certainty. The specific name is in

honor of Mr. Arthur Brune, who found the specimen on which the species is based.

Occurrence.—Zone above School Mine ledge in middle part of Rich Fountain formation (Jefferson City group) on east side of U. S. Highway 63 at its crest over Pilot Knob, that is, at elevation 1180 feet, in NW cor. SE¼ NW¼ sec. 27, T. 36 N., R. 8 W., Rolla quadrangle, Phelps County, Missouri.

Holotype.—Missouri School of Mines and Metallurgy, 7222.

APPENDIX

Lt. S. G. Tuell recently found a unique specimen near Fort Leonard Wood in south-central Missouri and kindly loaned it to us for study. This specimen represents a new species of the rather rare genus *Campbelloceras*, and we are naming it in honor of its discoverer.

CAMPBELLOCERAS TUELLI Miller and Cullison, n. sp.
Plate 28, figures 1–3

The holotype of this species is an internal mold of about a third of a volution of a phragmacone that was at least 55 mm. in diameter. The conch is rather gradually expanded orad and is subcircular in cross section but is distinctly depressed dorsoventrally. The width of the holotype increases from about 19 mm. near its adapical end to about 25 mm. near its adoral end. The dorsal zone of this specimen is, unfortunately, imbedded in a chert matrix that we have been unable to remove, but near its mid-length the conch is about 22 mm. wide and some 19 mm. high. No trace of the surface ornamentation of the test is preserved.

The sutures are directly transverse and essentially straight, but they form very slight lateral lobes. The camerae are moderately short, and twenty of them are represented, in whole or in part, by the holotype. Those in the adoral portion of this specimen are shorter than those in the adapical part of it, suggesting that we are dealing with a fully mature individual.

The siphuncle is ventral and marginal in position, and it appears to have been in contact (or very nearly so) with the ventral wall of the conch. Its diameter is equal to about one-fifth the width of the conch. It is composed of cylindrical segments and is almost certainly orthochoanitic in structure, though the relative length of the septal necks and the connecting rings can not be ascertained.

Remarks.—Only six or seven species have been described previously that are congeneric with this form. All of these come from the upper part of the Lower Ordovician, but geographically the genus is rather widespread, being known from Quebec, Vermont, Virginia, Missouri, and probably Newfoundland and Alabama. The conch of the form under consideration seems to be more strongly depressed than is that of any of the other known representatives of *Campbelloceras* except *C. hyatti* U., F., M., and F. (in which the sutures form a ventral lobe).

C. tuelli resembles rather closely *C. virginianum* of the Cotter horizon in Virginia, *C. brevicameratum* of the Powell horizon in the same state, and particularly *C. simplex* of the Cotter dolomite of Missouri. In all three of these species, the mature conch is slightly compressed laterally, rather than depressed dorsoventrally. Also, in *C. simplex* (Pl. 28, figs. 6–8) the siphuncle is relatively small and the camerae are shorter than are those of *C. tuelli*.

Occurrence.—The only known representative of this species was found in a residual chert boulder lying on the fourth member of the Roubidoux formation, on the west side of the road about 2¾ miles due south of Fort Leonard Wood and about 2 miles northwest of Big Piney, Pulaski County, Missouri. Its exact stratigraphic position is not known.

Holotype.—Private collection of Lt. S. G. Tuell of Plainville, Connecticut.

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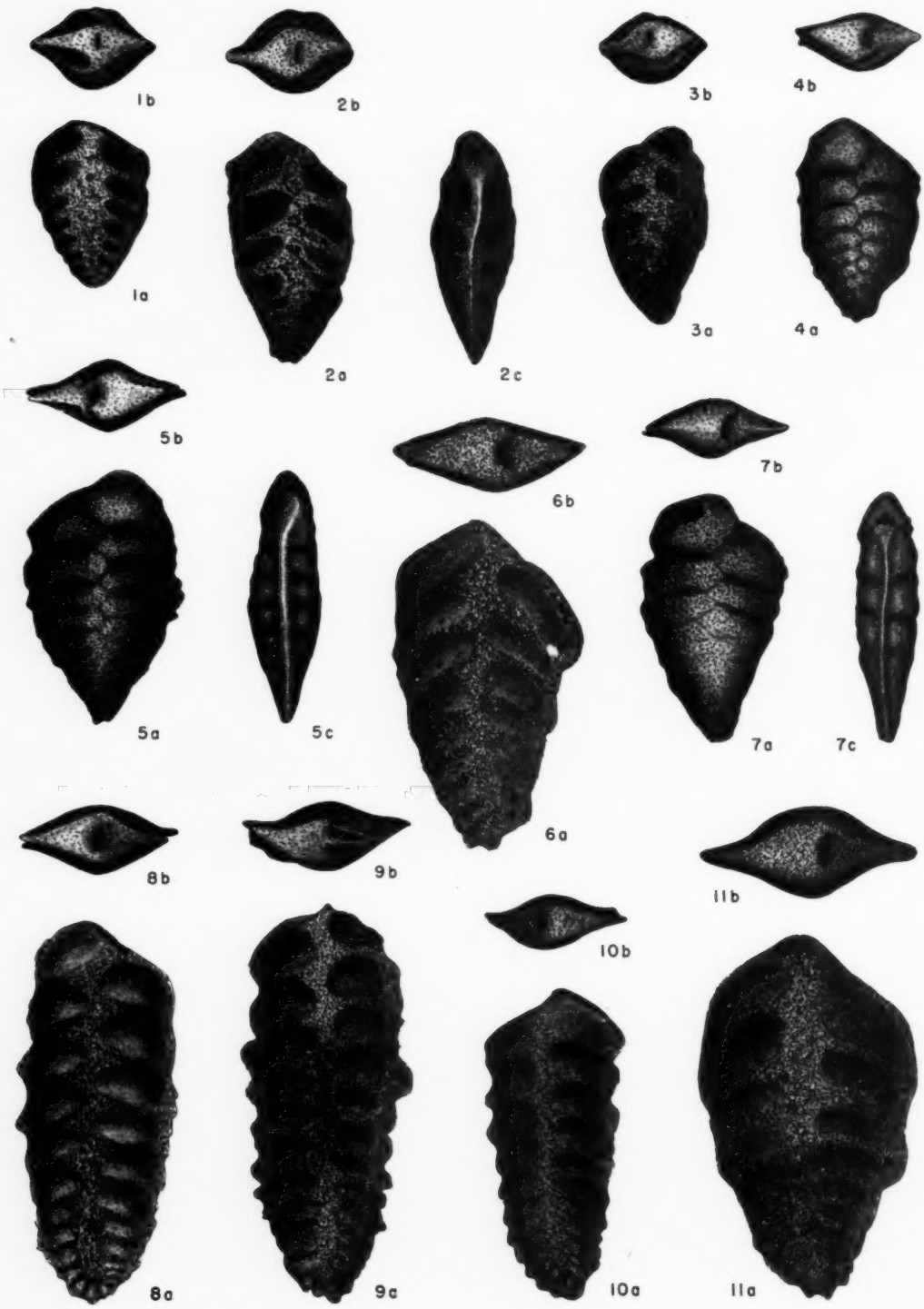

Stuckey—Tertiary Textulariidae

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 2, PP. 163–165, PL. 29, MARCH 1946

SOME TEXTULARIIDAE FROM THE GULF COAST TERTIARY[1]

CHARLES W. STUCKEY, JR.
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ABSTRACT—Four species, two of them are new, are described and figured. They were collected from material of Vicksburg Oligocene age at outcrops in Mississippi and from subsurface beds in the Gulf Coast of Texas.

FOR SOME years, the name *Textularia mississippiensis* Cushman, has been used to designate a number of similar forms. An effort to restrict the above name led the writer into the present work.

A study of well samples of supposed Vicksburg Oligocene age in Texas and an examination of surface beds composing the Vicksburg group of Mississippi revealed two species generally referred to as *Textularia mississippiensis* Cushman which are herein described as new.

The author wishes to express his appreciation for the invaluable assistance rendered by J. A. Cushman who supplied specimens, helpful criticisms and identifications of specimens. The author also wishes to thank Cecil G. Lalicker for assistance in some generic determinations and J. B. Garrett for use of the surface material. The writer is deeply indebted to M. B. Stephenson for the illustrations for without his assistance the paper would not have gone to press.

[1] Published with the permission of the Stanolind Oil and Gas Company.

Types of all species will be deposited with the Louisiana State University Museum, Baton Rouge, Louisiana.

SYSTEMATIC DESCRIPTIONS

Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA MISSISSIPPIENSIS (Cushman)

Plate 29, figures 6a, b, 7a–c, 11a, b

Textularia mississippiensis Cushman, 1922, U. S. Geol. Survey Prof. Paper 129, pl. 14, fig. 4, pp. 90, 125.

The original description is as follows: "Test elongate, fairly broad, thickest in the middle, thence thinning toward the periphery; in the end view biconvex, central portion curved; chambers low and broad especially in the early stages, becoming higher in the adult and often less broad so

EXPLANATION OF PLATE 29

FIGS. *1a, b—Textularia seligi* Stuckey, n. sp. *a*, Side view, *b*, Apertural view, Paratype (no. 3317) ×60. (p. 164)

2a–c—Textularia seligi Stuckey, n. sp. *a*, Side view, *b*, Apertural, *c*, Edge view, Holotype (no. 3315) ×70. (p. 164)

3a, b—Textularia seligi Stuckey, n. sp. *a*, Side view, *b*, Apertural view, Paratype (no. 3316) ×60. (p. 164)

4a, b—Spiroplectammina alabamensis (Cushman) *a*, Side view, *b*, Apertural view, Plesiotype (no. 3313) ×45. (p. 164)

5a–c—Spiroplectammina alabamensis (Cushman) *a*, Side view, *b*, Apertural view, *c*, Edge view, Plesiotype (no. 3314) ×45. (p. 164)

6a, b—Spiroplectammina mississippiensis (Cushman) *a*, Side view, *b*, Apertural view, Plesiotype (no. 3308) ×60. (p. 163)

7a–c—Spiroplectammina mississippiensis (Cushman) *a*, Side view, *b*, Apertural view, *c*, Edge view, Metatype (no. 3307) ×60. (p. 163)

8a, b—Spiroplectammina howei Stuckey, n. sp. *a*, Side view, *b*, Apertural view, Holotype (no. 3310) ×45. (p. 164)

9a, b—Spiroplectammina howei Stuckey, n. sp. *a*, Side view, *b*, Apertural view, Paratype (no. 3312) ×45. (p. 164)

10a, b—Spiroplectammina howei Stuckey, n. sp. *a*, Side view, *b*, Apertural view, Paratype (no. 3311) ×45. (p. 164)

11a, b—Spiroplectammina mississippiensis (Cushman) *a*, Side view, *b*, Apertural view, Plesiotype (no. 3309) ×50. (p. 163)

that the later chambers in the adult make a test less wide than at the earlier stages; sutures covered by a coarse layer meeting in the center and at the periphery, leaving the central portion of each chamber uncovered, periphery irregular, not definitely or regularly spinose; chamber walls smooth and finely perforate."

Dimensions of metatype, figs. 7a–c (no. 3307, from U. S. G. S. Locality 6455): Length, 0.61 mm.; Width, 0.38 mm.; Thickness, 0.18 mm.

Dimensions of plesiotypes, figs. 6a, b (no. 3308 from Karl E. Young Locality 4, Sample 5): Length, 0.82 mm.; Width, 0.51 mm.; Thickness, 0.15 mm.; figs. 11a, b (no. 3309, from Karl E. Young Locality 10, Sample 3): Length, 0.91 mm.; Width, 0.55 mm.; Thickness, 0.28 mm.

SPIROPLECTAMMINA HOWEI Stuckey, n. sp.
Plate 29, figures 8a–10b

Test elongate, about twice as long as broad, flattened, thickest in the middle, early coiled initial portion comprising about one-fifth of the test, sides nearly parallel in rectilinear portion which generally consists of a series of eight biserial chambers; chamber walls smooth, sutures depressed yet filled with arenaceous cemention material; median line broad, thickened and limbate; aperture an elliptical opening in the base of the last-formed chamber.

Dimensions of holotype, figs. 8a, b (no. 3310): Length, 1.27 mm.; Width, 0.49 mm.; Thickness, 0.22 mm.

Dimensions of paratypes, figs. 10a, b (no. 3311): Length, 1.05 mm.; Width, 0.50 mm.; Thickness, 0.18 mm.; figs. 9a, b (no. 3312): Length, 1.30 mm.; Width, 0.60 mm.; Thickness, 0.22 mm.

All specimens from Garrett and Washburn Locality 71, Sample C.

SPIROPLECTAMMINA ALABAMENSIS
(Cushman)
Plate 29, figures 4a, b, 5a–c

Textularia mississippiensis Cushman var. *alabamensis* Cushman, U. S. Geol. Survey Prof. Paper 133, p. 17, pl. 1, fig. 4, 1923.
Textularia mississippiensis var. *alabamensis* Cushman, Ellisor, A. C., Am. Assoc. Petroleum Geologists, vol. 17, no. 11, pl. 1, fig. 6.

The original description states: "Variety differing from the typical species in the more elongate form, somewhat thicker test, especially in the center, the less well defined peripheral carina, and the sutures excavated instead of being covered by an arenaceous layer."

Dr. Cushman[2] advised that while the original description may lead one to believe that the sutures are raised and limbate, this is not actually the case.

Dimensions of plesiotypes: figs. 4a, b (no. 3313), Length, 0.70 mm.; Width, 0.41 mm.; Thickness, 0.20 mm.; figs. 5a–c (no. 3314), Length, 0.88 mm.; Width, 0.55 mm.; Thickness, 0.25 mm. Both specimens from Karl E. Young Locality 10, Sample 3.

TEXTULARIA SELIGI Stuckey n. sp.
Plate 29, figures 1a–3b.

Test small, about twice as long as broad, sides nearly parallel in later half of the test, thickness at the median line nearly equal to width; wall smooth, sutures flush with the surface in early portion of the test, while in later portion, the narrow chambers form a depressed area between the raised and limbate sutures; median line prominent, composed of clear shell material; aperture, an elliptical opening at the base of the last-formed chamber.

Dimensions of holotype: figs. 2a–c (no. 3315), Length, 0.50 mm.; Width, 0.28 mm.; thickness, 0.18 mm.

Dimensions of paratypes: figs. 3a, b (no. 3316), Length, 0.50 mm.; Width, 0.31 mm.; Thickness, 0.20 mm.; figs. 1a, b (no. 3317), Length, 0.41 mm.; Width, 0.29 mm.; Thickness, 0.20 mm. All specimens from core at 10,480–90 feet, Stanolind Oil and Gas Co., no. 1 M. E. Giles.

Remarks.—This foraminifer was placed in the genus *Textularia*, for in hundreds of samples where it was observed, only the form with the bulbous proloculum was noted. *T. seligi* can hardly be the megalosphaeric form of *S. mississippiensis* (Cushman) as it occurs in strata younger than those containing this species. *T. seligi* differs from *S. mississippiensis* in its much smaller size, its extreme thickness at the middle due to a median ridge of clear shell material, and its much narrower width. It differs from *S. alabamensis* (Cushman) in

[2] Personal Communication.

having raised and limbate instead of depressed sutures.

DESCRIPTIONS OF LOCALITIES

United States Geological Survey Locality 6455. Pearl River bridge at Byram, Mississippi.

Karl E. Young Locality 4, Sample 5. At fall (nearest the Mississippi River) in Glass Bayou adjoining the National Park Cemetery at Vicksburg, Mississippi.

Karl E. Young Locality 10, Sample 3. Byram marl on the west bank of Pearl River about one-quarter of a mile south of Illinois Central Railway depot at Byram, Mississippi.

J. B. Garrett and C. F. Washburn Locality 71, Sample C. Red Bluff on the Chickasawhay River two and one-half miles north of Hiwannee, Mississippi.

Stanolind Oil and Gas Co., no. 1 M. E. Giles, Old Ocean Field, Brazoria County, Texas. Core at 10,480–90 feet.

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 2, PP. 166–171, PL. 30, MARCH 1946

MISSISSIPPIAN ALGAL LIMESTONES FROM THE VICINITY OF ST. LOUIS, MISSOURI

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Colorado School of Mines

ABSTRACT—Algal limestones, which form a distinctive thin zone of nodular and mottled limestones probably at the base of the Ste. Genevieve formation, have been observed at several localities around the outskirts of St. Louis. The study shows seven varieties of algae present as well as Foraminifera, ostracods, and some debris of other organisms. One new algal species, *Girvanella maplewoodensis*, is described.

INTRODUCTION AND ACKNOWLEDGMENTS

CALCAREOUS algae and bands and lenses of algal limestones are common in the Mississippian formations of England and Belgium and recently some algal material has been found by the writer in the Leadville formation of Central Colorado. It appeared logical that algae should occur in the type localities of the Mississippi Valley, so the author requested several of his friends in Missouri to look for them. Several years ago Dr. Courtney Werner of Washington University, St. Louis, found some and arranged for the author to visit the locality. Later, Mr. John M. Clauser discovered similar material at the same horizon at other localities in the St. Louis region.

The material from the above localities is described and illustrated in the present paper with the hope that it will stimulate a search for and study of algal material and that it may throw light on the conditions under which the limestones were deposited. The forms herein described belong to low filamentous types, but higher types should also occur, although they were not observed in the present study.

GEOGRAPHICAL DISTRIBUTION

Specimens of algal limestone were first observed and collected in the Terminal Railroad cut just north of the Big Bend Quarry between Big Bend Road and Laclede Station Road in Maplewood, on the outskirts of St. Louis. The present study is based mainly on material collected at this locality. Later, thanks to John M. Clauser, an almost identical section was visited at Stolle's Quarry along the Illinois bank of the Mississippi River, about two and a half miles southeast of Cahokia, or four or five miles south of East St. Louis. Here algal limestones of the same types occur in similar sequence.

The writer is grateful to Dr. Courtney Werner, Mr. Clauser, and Jack Dann for specimens and assistance in the field, and to L. W. LeRoy and J. C. Haff of the Colorado School of Mines for assistance in preparing the photographs and illustrations.

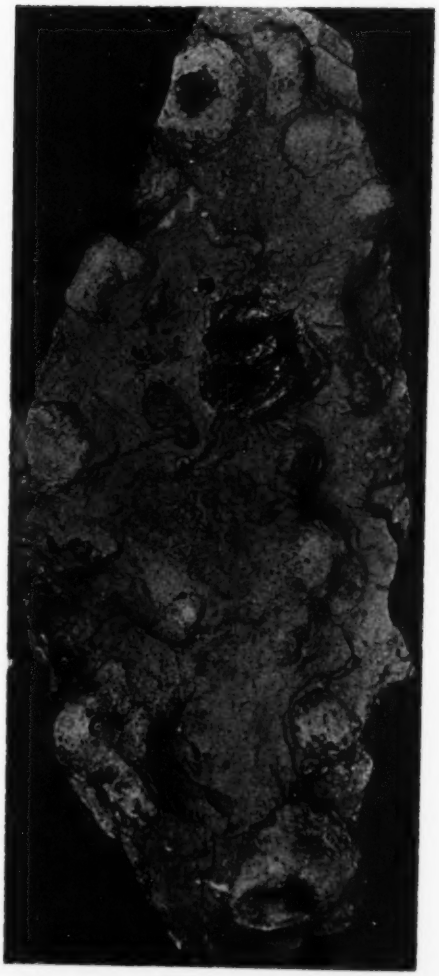
STRATIGRAPHIC POSITION AND DISTRIBUTION

The algal limestones occur either near the base of the Ste. Genevieve formation or in the uppermost St. Louis limestone. There is some uncertainty in the minds of the local geologists as to where the boundary should be drawn, some placing it above the algal horizon and some below.

Fenneman (1911, p. 24) mentioned a peculiar occurrence of local beds of nodular limestone in the upper St. Louis limestone, "in which spherical concretions of limestone are embedded in a matrix of the same material. The concretions, which have a diameter

PLATE 30

FIGS. *1*—Algal limestone, Type 1. A weathered surface showing the nodular algal colonies. ×1. (p. 167)
2—Algal limestone, Type 1. A polished surface of limestone similar to figure 1, but with larger and more irregular algal colonies. ×1. (p. 167)
3—Algal limestone, Type 2. A polished surface. ×1. (p. 168)
4—*Girvanella maplewoodensis* Johnson n. sp. ×50. (p. 169)



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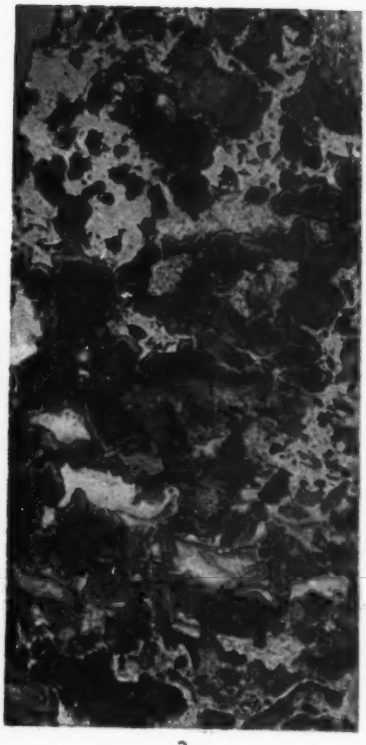

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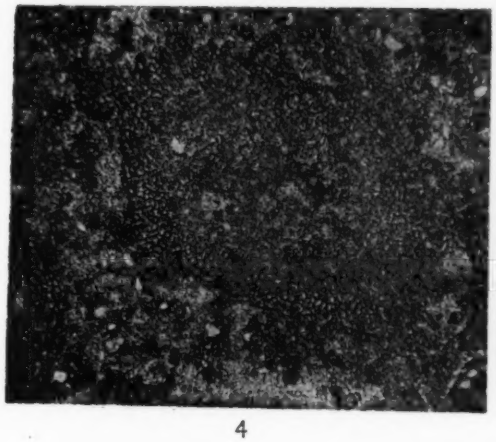

4

Johnson—Mississippian Algae Limestone

of 1 to 2 inches, are dense and hard and many of them are concentrically marked. The matrix is apparently less pure, coarser in texture, and in places shaly. Here and there such beds contain or adjoin thin bands of green shale or clay and in many beds of this character the limestone nodules, though not formed within the clay, protrude prominently from the surface of the limestone and indent the clay. Elsewhere interbedded limestones and clays both contain such concretions." This description fits the algal horizon discussed in this paper. At that time algal limestones were little known and the Mississippian formations were not so well differentiated as they are now.

On the other hand Weller and St. Clair (1928, p. 220) record a bed a foot or less in thickness filled with the pebble-like remains of calcareous algae about ten feet from the base of the Ste. Genevieve formation at Little Rock about two miles north of Ste. Genevieve, Missouri.

To the writer, who has had but little field experience in the region and must depend largely on the literature for a knowledge of the formations involved, it seems that the algal horizon represents a special deposition facies suggestive of a lagoonal environment, and that it more logically fits at the beginning of the Ste. Genevieve type of granular and oölitic limestone deposition rather than in the more massive, fine-textured St. Louis limestone. Also if the unconformity between the formations recorded by Weller and St. Clair (1928, p. 222) is present at St. Louis, the algal facies would seem more likely to occur just above rather than below the unconformity.

If this interpretation is correct, the algal limestones ocur in the lower part of the Ste. Genevieve, starting practically at the base of the formation and having their greatest development ten or twelve feet higher. Algal pellets extend five or six feet still higher into the lower part of beds carrying abundant marine fossils. The detailed section is given below.

ALGAL LIMESTONES—BASAL STE. GENEVIEVE FORMATION

Section measured along railroad cut by Big Bend Quarry, Maplewood, Missouri. Measured by J. Harlan Johnson and Jack Dann July 22, 1940.

		Feet
Top of cut; clay soil.		
19	Gray limestone, somewhat oölitic. Shows coarse cross-bedding. Contains algal pellets (Type 1) up to 1½″ across (mostly small), also numerous *Bellerophon*-type gastropods, some small brachiopods, bryozoa fragments, crinoid stems, and syringopora corals. In one place the algal colonies were intergrown with the syringopora.	2′2½″
18	Limestone, light gray, cross-bedded, oölitic. A few small algal pellets at and near the top.	3′5″
17	Limestone, gray, massive, laminated. Algal pellets (Type 1) up to 1½″ in diameter scattered sparingly throughout.	1′11″
16	Algal limestone, brownish gray to greenish gray, mottled (Type 2).	6″
15	Shale, greenish gray, calcareous.	¾″
14	Limestone, gray, fine-grained	3″
13	Shale, greenish gray. Contains a few small algal pellets.	1″
12	Limestone, gray, fine-grained.	2¾″
11	Calcareous shale, greenish gray, with abundant algal pellets.	6½″
10	Algal pellet limestone. Algal colonies up to 3″ across. Average 1½″ to 2″.	1′6″
9	Shaly limestone.	3″
8	Limestone, gray, slightly oölitic. Scattered small algal pellets of Type 1, becoming more abundant at base. Also a few of Type 2 at base.	11″
7	Algal limestone, brownish gray, mottled. Type 2.	1′10″
6	Limestone, gray, finely oölitic, conchoidal fracture.	1′2″
5	Algal limestone. Algal pellets Type 1 up to 3″ across (averaging 1½″) in an oölitic matrix.	1′10″
4	Shale, greenish gray.	1″
3	Algal pellet limestone (Type 1).	5″
2	Shale, greenish gray.	3½″
1	Limestone, light gray, slightly oölitic.	2′1½″
Base of exposure		

THE ALGAL LIMESTONES

Lithology: As observed in the field or in hand specimens the algal limestones are of two distinct types—(1) a pellet limestone, (2) a massive, mottled limestone.

Type 1 is a light-gray pellet limestone which in some instances superficially resembles a breccia (pl. 30, fig. 2). It is composed of rounded, irregular, algal colonies embedded in a fine ground mass. The algal colonies range in size from a fraction of an inch up to a maximum of three inches.

The majority are an inch to an inch and a half in diameter. The smaller ones are nearly spherical but they tend to become flattened as they attain greater size. The flat surfaces are usually parallel to the stratification. The surfaces appear smooth except for a few rounded protuberances. With a hand lens, however, the surface is seen to be slightly pitted and felted.

The ground mass is fine-grained. On weathering it may become dark-gray or yellow-brown, whereas the pellets usually bleach to a light gray. The algal pellets resist weathering more than the ground-mass and stand out on exposed surfaces (pl. 30, fig. 1).

Type 2 is a dark, greenish-gray, mottled limestone (pl. 30, fig. 3). In its most typical development it consists of a great number of dark, irregularly rounded, finger-shaped or stag horn-like algal colonies closely packed together in a light, sandy-textured ground-mass. Frequently the colonies are so tightly packed that they appear to coalesce, forming masses and bands. Where more widely spaced, the colonies assume forms suggestive of small, branching stag horns or long turret or finger like masses.

On weathered surfaces the algal material darkens whereas the ground mass becomes lighter, producing a contrasting mottled rock. The weathered surface is rough but the colonies do not etch out in such strong relief as Type 1.

Micro-structure: At a magnification of ×50 the pellets of limestone (Type 1) are seen to consist of a dark mat of algal filaments enclosing organic debris, small organisms, and particles of sediment with a ground-mass of clear crystalline calcite. The details are summarized in Table I.

TABLE 1. ORGANIC CONTENT ALGAL LIMESTONE: LOWER STE. GENEVIEVE, MAPLEWOOD, (ST. LOUIS) MISSOURI.

Organism	Bed Number										
	19	18	15	14	13	10	8	7	6	5	3
Algae											
Girvanella						x					
Algal type 1	x	x	x	x	x	x	x	x	x	x	x
2				*			*	*	*	*	
3					*	*		*			
4			*			*	*		*		
5								*		*	
6?		*			*						
Small Foraminifera	*	*	*	*	*	*	*		*	*	*
Endothyra	*										
Echinodermal debris	*			*		*					
Bryozoan shreds	*			*		*	*			*	
Brachiopods	*										
Gastropods						*			*		
Shell fragments	*			*		*				*	
Ostracods				x		*	*	*	*	*	
Coral fragment	*										
Oöliths						*				*	*

x Abundant. Beds 3, 5, 6, 8, 10, 13, 14, 18, 19 are Type 1 limestone.
* Present but not abundant. Beds 7 & 16 are Type 2 limestone.

Limestones of Type 2 are very similar in micro-structure and contain the same types of algae. The difference in character seems to result from the fact that in Type 1 the algae are largely restricted to well-defined compact colonial masses which form the pellets, whereas in Type 2 the entire rock is a mass of intergrown, irregular, poorly-defined and less compact algal colonies. As originally deposited the limestone appears

to have been rather porous and exhibits considerable recrystallization which seems to have occurred almost contemporaneously with deposition and has affected the algal material much more than the enclosed animal remains.

SYSTEMATIC DESCRIPTION

The algal filaments are preserved as molds in finely divided calcite particles. Eight different varieties were recognized. Of these only two had characteristics sufficiently distinctive to justify being named. The others differ mainly in size (diameter) of the filaments, so are merely called varieties 1 to 6. Whereas these varieties occur associated together and are intimately mixed, it is noteworthy that the differentiation is fairly clean cut in that intermediate sizes between the various types were not observed. There is some question whether variety 6 is really algal.

Genus GIRVANELLA Nicholson and Etheridge, 1880

GIRVANELLA MAPLEWOODENSIS Johnson, n. sp.

(Plate 30, figure 4)

Holotype: Slide No. 437 from specimen JA 1782, Johnson Collection, Colorado School of Mines.

Description: Well-defined tubes, circular in outline; highly twisted and entwined; diameter between .008 and .009 mm.; have clearly defined walls of dark granular structure; in some cases the colony assumes a sharply outlined, nearly spherical form; at other times an irregular, poorly defined mass.

Remarks: Some of the colonies were built around nuclei of foreign material such as small crinoidal fragments; other colonies show no such nucleus. In the well-defined spherical colonies other algal forms are absent or rare except sometimes as an outer coating. The irregular, poorly outlined colonies which more or less fade out in the ground mass may also contain considerable quantities of other types of algal filaments. The tube diameter, measured in over 50 specimens of limestone, is surprisingly constant—between .008 and .009 mm.

Species closely resembling *G. maplewoodensis* in all features except diameter of tube have been described from the English Mississippian. They are *G. minuta* Wethered, 1890—tube diameter 0.007 mm. and *G. incrustans lucii* Wethered, 1890—tube diameter 0.01 mm.

Occurrence.—Bed 10, Terminal Railroad cut by Big Bend Quarry, Maplewood, St. Louis County, Missouri.

Genus ORTONELLA Garwood, 1914

ORTONELLA cf. O. KERSHOPENSIS Garwood

Ortonella kershopensis, Garwood, 1931, Geol. Soc. London, Quart. Jour., vol. 87, pp. 111, 139, pl. 13, fig. 3.

Ortonella kershopensis, Pia, 1937, Deuxième Congrès des études de stratig. Carbonifère, C.R., pp. 791–792.

Garwood (1914, p. 139) described *O. kershopensis* from northeastern England as consisting of tube-like stems arranged in slightly radiating bundles, forming conspicuous tufts at intervals where rapid dichotomous branching occurs; tubes vary from .01 to 0.125 mm. in diameter; angle of divergence of branches 45° to 50°.

Several of the slides studied contain material suggesting this genus. However, the preservation is poor and other algal forms are intimately associated. One slide yielded a fairly well-defined specimen showing details of branching and permitted fairly accurate measurement. The results fit the description of *O. kershopensis* except for a slightly greater tube diameter (.13 to .145 mm.). Having only one, not-too-well-preserved specimen, which shows considerable range in tube diameter, the writer does not feel justified in erecting a new species and merely indicates its close affinity to *O. kershopensis*. Some of the material grouped under Algal Threads, variety 4, discussed later, may also belong to this species.

ALGAL THREADS

Variety 1: Filaments .004 to .005 mm. in diameter. The majority show branching, commonly at a wide angle (45° to 60°); however, a number of cases were observed with divergence of approximately 40°.

This type is by far the most common form in all the specimens studied. In some slides it is the only form present. In the majority it comprised more than 60 per cent of all the algal material present. It occurs as

pure colonies, as intergrowths with coarser forms, as fillings of large Foraminifera and ostracods, and as coatings around fragments of organic debris (crinoid stem fragments, bryozoan shreds, pieces of shell).

Variety 2: Filaments with diameters ranging from .007 to .009 mm., angle of branching commonly approximately 60°. This type is relatively rare. It is most common in the lower beds of the section with a maximum development in bed 5, becoming rarer at higher levels; it was not observed above bed 14. However, at the maximum it comprises less than 20 per cent of the algal material present. A few patches, representing essentially pure colonies, were observed, but usually it is associated with variety 1.

Variety 3: Filaments having a diameter of .011 to .012 mm.; branching not clearly observed. This form is rare, observed only on five slides. It occurs as patches or colonies and is associated with variety 1 in beds 7, 10 and 13.

Variety 4: Coarse filaments with a diameter .014 to .016 mm.; usually branching at rather wide angles; relatively rare; occurs as colonies and associated with variety 1; best developed in bed 15. Some of this material may represent *Ortonella* cf. *O. kershopensis* Garwood. Most of it is too poorly preserved to show much beyond the approximate diameter of the tube.

Variety 5: Very coarse filaments with diameter .05 to .055 mm.; no indications of branching. Very rare; found in only a few slides from beds 5 and 7; occurs in colonies of Type 1 and the coarse tubes are filled with filaments of Type 1.

Variety 6: Extremely coarse tubes; diameter .08 mm. There is considerable doubt if these are algal. They cut through the algal mat of smaller types and have the appearance of being somewhat later in origin. They may very well represent worm borings. Found only in two slides.

CLASSIFICATION

These specimens are interpreted as representing relatively low algal forms. Type 1 and most of the others which do not show a very sharply defined wall structure probably belong among the Cyanophyceae or blue-green algae.

There is a difference of opinion as to the systematic position of *Girvanella*. Pia (1937, p. 782) puts it in the broad group of Porostromata, which may belong either to the Cyanophyceae or the Chlorophyceae or green algae.

Ortonella is considered to belong to the Chlorophyceae, possibly among the Codiaceae.

OTHER ORGANISMS PRESENT

The organisms other than algae found in the limestones are indicated in Table I. Of these foraminifera and some of the ostracods were entire and seem to have been living essentially with the algae. One complete small brachiopod and several small gastropods were also observed. All the other organisms are represented by fragments usually frayed and worn.

Foraminifera of small size were found in all the slides studied. Large *Endothyra* occurs abundantly in bed 19. Numerically the Foraminifera were the most abundant animal remains present.

Echinoderm fragments are themost abundant animal remains in terms of volume. The majority are pieces of stem columnals of blastoids or crinoids, although a few suggest fragments of echinoid spines and plates. Practically all are broken or worn. Many are coated by fine algal filaments which in some cases appear to penetrate the margins slightly.

Ostracods are relatively abundant in bed 14, elsewhere they are represented only by a few stray carapaces or moults.

Bryozoan shreds are present in the more massive limestones but are abundant only in bed 19.

Shell fragments, mainly of brachiopods, were found in a number of slides but are of rare occurrence except in bed 19.

Corals are represented by a single cross-section of *Syringopora* from bed 19. However, remains of this coral were observed associated with algal material on the rock outcrop of that bed.

Gastropods and fragments of gastropod shells occur in small numbers.

ALGAL DUST

It is interesting to note that while in the pellet limestones the algal colonies are light colored, almost white in some cases, yet in

thin sections they appear very dark gray or almost black. The writer has been puzzled by the same phenomena in many other algal limestones, even those white in color. In the present case the algal filaments are preserved as molds in extremely fine-grained calcite. The calcite particles are so small they diffuse the light and make it appear dark colored. Probably the fine calcite is the calcium carbonate precipitated by the algae as they grew. The material appears to be the same as that found in some of the classic Mississippian algal limestones of England described by Wood (1941, p. 193) as "algal dust."

OÖLITHS

Oöliths or individual oölitic bodies were observed in a number of slides and specimens although not abundantly. A few thin sections show what appear to be incipient oöliths in the process of formation where an incomplete ring of radially arranged needles of crystalline calcite occurs in the midst of a mat of algal filaments, apparently surrounding a nucleus of algal material and penetrating a spongy algal mass. The ensemble makes one think of Kaisin's (1937) suggestion that oöliths might be formed by colonies of lime secreting bacteria developing in or upon an organic mass in tranquil water.

DEPOSITIONAL ENVIRONMENT

The character of the organisms studied suggests deposition in shallow tranquil water such as might occur in a lagoon or estuary. Clastic sediment is rare and occurs as fine particles. The rock is essentially organic in origin. The algae belong to low types, Cyanophycaea and Chlorophycaea, and probably represent a rapid luxuriant growth. The ostracods are smooth shelled, unornamented types such as usually occur in fresh, brackish, or near shore waters rather than in typical marine environments. Bed 19 at the top of the algal section is the only one having typically shallow marine characteristics and fauna. In the lower part of that bed the algae are present in limited numbers mixed with corals and small brachiopods, but they abruptly disappear as the bed becomes a typical marine fossiliferous limestone.

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BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1944

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THE FOLLOWING bibliography contains 75 titles of papers which deal partly or exclusively with Foraminifera recorded during the year 1944. One title is added for the year 1943.

Publications in the following list in which new forms of Foraminifera are described, are, as follows: 3, 4, 9–13, 16–20, 25–27, 30-32, 34-38, 41, 50–52, 57, 66, 69, and 70, a total of 31.

In the literature for the year 1944 there are recorded 10 new genera, 178 new species, 30 new varieties (or subspecies), 6 new names, 15 *nomina nuda*, 4 homonyms, and 89 forms to which the *nomenclatura aperta* has been applied.

Stratigraphically the new genera are distributed as follows: Permian 1, Paleocene 2, Middle Eocene 4, Miocene 1, Eocene to Recent 1, and Pliocene to Recent 1. They are allocated to the following families: Amphisteginidae 1, ? Camerinidae 1, Discocyclinidae 1, Fusulinidae 1, Miliolidae 1, Planorbulinidae 1, Rotaliidae 2, and Valvulinidae 2.

Out of a total of 208 new species and varieties of Foraminifera 23 per cent are from Cenozoic (Quaternary and Recent), 55.5 from Cenozoic (Tertiary), 14 from Mesozoic, and 7.5 from Paleozoic strata. The new forms are distributed as follows: Carboniferous 5, Permian 11, Lower Cretaceous 18, Upper Cretaceous 11, Paleocene 19, Eocene 28, Upper Eocene-Oligocene 9, Oligocene 12, Miocene 44, Pliocene 3, Pleistocene 1, and Recent 48 new forms. No new forms are recorded from Cambrian, Silurian, Devonian and Jurassic beds.

Homonyms.—The following names, published during 1944, are regarded as homonyms for which substitute names should be proposed by their respective authors:

Globigerina baroemoenensis LeRoy var. *quadrata* LeRoy, preoccupied by White, 1928

Nonion browni Cole, preoccupied by d'Orbigny, 1839

Rotalia umbonata LeRoy, preoccupied by Silvestri, 1898

Uvigerina canariensis d'Orbigny var. *nuttalliana* Franklin, preoccupied by Howe and Wallace, 1932

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Ammobaculites dentonensis Tappan, **66**, p. 560. Cretaceous, Texas. New name for *Ammobaculites variabilis* Tappan, 1940, non *Verneuilina* (*Ammobaculites*) *variabilis* Brady, 1884.
——— *hendricksi* Franklin, **41**, p. 305, pl. 44, fig. 8. Lower Oligocene, Carapita formation, Venezuela.
——— *laevigata* Lozo, **52**, p. 538, pl. 2, figs. 2, 3, text fig. 14. Lower Cretaceous, Goodland formation, North Texas.
Angulogerina virginiana Cushman, **18**, p. 25, pl. 4, fig. 23. Lower Eocene, Wilcox formation, Virginia.
Anomalina packardi Bandy, **3**, p. 373, pl. 61, fig. 7, Middle Eocene, Oregon.
Articulina alticostata Cushman, **25**, p. 16, pl. 4,

[1] (The numbers in bold-face type following the author's name in the Index refer to the publication listed in the preceding Bibliography.)

figs. 10–13. Recent, Pacific, Fiji (Mokaujar anchorage).

——— *canui* Cushman, **25**, p. 6, pl. 1, figs. 12–14. Eocene, France. For: *Articulina gibbosula* Terquem, 1882, (non d'Orbigny, 1846), Mém. Soc. géol. France, (3), vol. 2, p. 151, pl. 15, fig. 25 (non fig. 26).

——— *carinata* Cushman, **25**, p. 15, pl. 3, figs. 18–20. Recent, Pacific, Fiji (Mokaujar anchorage), 12 fathoms. For: *Articulina lineata* Cushman, 1932, (non Brady, 1884), Bull. 161, U. S. Nat. Mus., pt. 1, p. 47, pl. 11, figs. 1, 2.

——— *crespinae* Cushman, **25**, p. 10, pl. 2, figs. 1–3. Miocene, Balcombian, Victoria, Australia.

——— *elongata* Cushman, **25**, p. 16, pl. 4, figs. 7–9. Recent, Pacific, Fiji (Mokaujar anchorage).

——— *fijiensis* Cushman, **25**, p. 15, pl. 4, figs. 1–6. Recent, Pacific, Fiji, shallow waters (Mokaujar anchorage).

——— *jacksonensis* Cushman, **25**, p. 7, pl. 1, fig. 15. Eocene, Jackson formation, Mississippi.

——— *pacifica* Cushman, **25**, p. 17, pl. 4, figs. 14–18. Recent, Pacific, Fiji (Mokaujar anchorage). For: *Articulina sulcata* Brady, 1884 (non Reuss, 1850), Rep. Voyage Challenger, Zool., vol. 9, p. 183, pl. 12, figs. 12, 13; for *Articulina sulcata* Cushman, 1917 (non Reuss, 1850), Bull. 71, U. S. Nat. Mus., pt. 6, p. 60, pl. 22, fig. 5; for *Articulina sulcata* Cushman, 1932 (non Reuss, 1850), Bull. 161, U. S. Nat. Mus., pt. 1, p. 47, pl. 11, figs. 3, 4; for *Articulina sagra* Heron-Allen and Earland, 1915, (non d'Orbigny, 1839), Trans. Zool. Soc. London, vol. 20, p. 585, pl. 45, figs. 22–25; and for *Articulina conico-articulata* Cushman, 1917, (non Batsch, 1791), Bull. 71, U. S. Nat. Mus., pt. 6, p. 58, pl. 22, fig. 6.

——— *parri* Cushman, **25**, p. 10, pl. 3, figs. 7–10. Miocene, Balcombian, Victoria, Australia.

——— *paucicostata* Cushman, **25**, p. 14, pl. 3, figs. 13, 14. Recent, off Dry Tortugas, Florida, 7 fathoms.

——— *victoriana* Cushman, **25**, p. 10, pl. 2, figs. 4, 5. Miocene, Balcombian, Victoria, Australia.

Astacolus comanchensis Lozo, **52**, p. 555, pl. 2, fig. 1. Lower Cretaceous, Kiamichi formation, northern Texas.

——— *subtumidus* Bandy, **3**, p. 368, pl. 60, fig. 7. Middle Eocene, Oregon.

Asterocyclina see *Discocyclina*.

Baggina gibba Cushman and Todd, **36**, p. 104, pl. 16, fig. 8. Pliocene, Italy.

——— *philippinensis* (Cushman, 1921) var. *pilulifera* Cushman and Todd, **36**, p. 105, pl. 17, fig. 4. Recent, off Cape Byron, Australia.

——— *pulchra* Cushman and Todd, **36**, p. 100, pl. 15, fig. 13. Oligocene, Germany. For: *Baggina parisiensis* (Cushman, 1928), (non *Globigerina parisiensis* d'Orbigny, 1850), Bull. Soc. Scie., Seine-et-Oise, (2), vol. 9, p. 55, pl. 3, fig. 3.

Bathysiphon irregularis LeRoy, **50**, p. 13, pl. 5, fig. 24. Miocene, Central Sumatra.

——— *perampla* Cushman and Goudkoff, **32**, p. 53, pl. 9, fig. 1. Upper Cretaceous, California.

Bigenerina telisaensis LeRoy, **50**, p. 15, pl. 8, figs. 52, 53. Miocene, Central Sumatra.

Bolivina bilaensis LeRoy, **50**, p. 28, pl. 1, figs. 27, 28. Miocene, Central Sumatra.

——— *contorta* LeRoy, **50**, p. 28, pl. 8, figs. 25, 26. Miocene, Central Sumatra.

——— *floridana* Cushman, 1918, var. *imporcata* Cushman and Renz, **33**, p. 78. New name for: *Bolivina floridana* Cushman, 1918, var. *regularis* Cushman and Renz, 1941, (non *Bolivina regularis* Nuttall, 1928), Contr. Cushman Lab. Foram. Research, vol. 17, p. 17, pl. 3, fig. 7. Oligocene-Miocene, Venezuela.

——— *jacksonensis* Cushman and Applin, 1926, var. *tumeyensis* Cushman and Simonson, **34**, p. 199, pl. 32, fig. 16. Oligocene (or upper Eocene ?), Tumey formation, California.

——— *media-costata* LeRoy, **50**, p. 29, pl. 8, figs. 29, 30. Miocene, Central Sumatra.

Buliminella barbati Cushman and Simonson, **34**, p. 197, pl. 32, fig. 10. Oligocene (or Upper Eocene ?), Tumeu formation, California.

Bullopora irregularis Lozo, **52**, p. 559, pl. 1, fig. 9. Lower Cretaceous, Goodland formation, North Texas. For: *Bullopora sp.* Tappan, 1940, Jour. Paleont., vol. 14, p. 115, pl. 18, fig. 7.

CAMAGUEYIA gen. nov. Cole and Bermudez, **11**, p. 5. Fam. Valvulinidae. Genotype: *Camagueyia perplexa* Cole and Bermudez, 1944 (ut infra). Middle Eocene.

——— *perplexa* Cole and Bermudez, **11**, p. 5, pl. 1, figs. 2, 3. Middle Eocene, Cuba.

Cassidulina algida Cushman, **26**, p. 35, pl. 4, fig. 24. Recent, Atlantic, off coast of New England, 10–18 fathoms.

——— *inflata* LeRoy, **50**, p. 37, pl. 4, figs. 30, 31. Miocene, Central Sumatra.

——— *symmetrica* LeRoy, **50**, p. 37, pl. 5, figs. 51, 52. Miocene, Central Sumtra.

Cibicides celebrus Bandy, **3**, p. 374, pl. 61, fig. 8. Middle Eocene, Oregon. For: *Cibicides sassei* Cushman and Dusenbury, 1934, (non Cole, 1927), Contr. Cushman Lab. Foram. Res., vol. 10, p. 64, pl. 9, fig. 5.

——— *damoeliensis* LeRoy, **50**, p. 42, pl. 2, figs. 16–18, 25–27. Miocene, Central Sumatra.

——— *delicatus* LeRoy, **50**, p. 42, pl. 2, figs. 19–21. Miocene, Central Sumatra. (Note: *cave: Cibicides deliquatus* Finlay, 1940).

——— *malayaensis* LeRoy, **50**, p. 43, pl. 2, figs. 10–12. Miocene, Central Sumatra.

——— *subcarinatus* Cushman and Deaderick, **30**, p. 341. Upper Cretaceous, Arkansas. New name for *Anomalina coonensis* W. Berry, 1929, (non *Truncatulina coonensis* W. Berry, 1929), Proc. U. S. Nat. Mus., vol. 76, Art. 19, p. 14, pl. 2, figs. 22–24.

Conorbina conica Lozo, **52**, p. 562, pl. 2, fig. 7. Lower Cretaceous, Glen Rose formation, North Texas. (Note: *cave Conorbina conula* Brotzen, 1940.)

Cornuspira fragilis LeRoy, **50**, p. 16, pl. 8, figs. 41, 42. Miocene, Central Sumatra.

Coskinolina adkinsi Barker, **4**, p. 206, pl. 35, figs. 1–4. Lower Cretaceous, Texas.

Cribrostomoides cretacea Cushman and Goudkoff, **32**, p. 54, pl. 9, fig. 4. Upper Cretaceous, California.

Dentalina alabamensis Cushman, **19**, p. 35, pl. 5, figs. 18–21. Paleocene, Naheola formation, Alabama.

——— *eocenica* Cushman, **19**, p. 36, pl. 6, fig. 1. Paleocene, Naheola formation, Alabama. For: *Nodosaria pauperata* Plummer, 1926 (1927), (non d'Orbigny, 1846), Univ. Texas Bull., 2644, p. 29, pl. 5, figs. 17, 18; and for: *Dentalina cf. pauperata* Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 29, pl. 5, figs. 17, 18.

——— *spira* Cooper, **12**, p. 348, pl. 54, figs. 1, 2. Paleocene, Porters Creek formation, Illinois.

——— *virginiana* Cushman, **18**, p. 22, pl. 4, figs. 8, 9. Lower Eocene, Wilcox formation, Virginia.

——— *wilcoxensis* Cushman, **27**, p. 8, pl. 1, figs. 5, 6. Eocene (Wilcox), Bashi formation, Alabama. For: *Dentalina sp.* Cushman and Todd, 1942, Contr. Cushman Lab. Foram. Res., vol. 18, p. 30, pl. 5, fig. 20.

Discocyclina (*Discocyclina*) *aguerreverei* Caudri, **9**, p. 11, pl. 2, figs. 8, 11; pl. 3, fig. 13; pl. 4, fig. 17. Paleocene, Venezuela.

Discocyclina (*Asterocyclina*) *nassauensis* Cole, **10**, p. 79, pl. 1, fig. 16; pl. 2, figs. 1, 2, 5, 6; pl. 12, figs. 5, 6; pl. 14, figs. 1–8. Upper Eocene, Ocala Limestone, Florida.

Discorbis javana LeRoy, **51**, p. 87, pl. 7, figs. 1–3. Miocene, West Java.

Ellipsonodosaria indica LeRoy, **51**, p. 79, pl. 1, fig. 24. Miocene, West Java.

Elphidium concinnum Nicol, **57**, p. 179, pl. 29, figs. 5, 9. Recent, Pacific, off coast of Lower California, Mexico. For: *Elphidium crispum* Cushman and Grant, 1927, (non Linné, 1758), Trans. San Diego Soc. Nat. Hist., vol. 5, no. 6, figs. 2a and b; and for: *Elphidium crispum* Cushman and Valentine, 1930, (non Linné, 1758), Contr. Geol. Dept. Stanford Univ., vol. 1, no. 1, p. 21, pl. 5, figs. 12a, b.

——— *excubitor* Nicol, **57**, p. 178, pl. 29, figs. 4, 8. Recent, Pacific, off west coast of Mexico.

——— *fax* Nicol, **57**, p. 177, with three subspecies, *ut infra*. Lower Pleistocene, California, and Recent, west coast United States of America.

——— ——— ——— subspec. *barbarense* Nicol, **57**, p. 178, pl. 29, figs. 10, 12. Lower Pleistocene, California. For: *Polystomella crispa* Bagg, 1912, (non Linné, 1758), U. S. Geol. Surv. Bull. 513, p. 90, pl. 27, figs. 13–20; pl. 28, figs. 1–6.

——— ——— ——— subspec. *fax* Nicol, **57**, p. 177, pl. 29, figs. 3, 11. Recent, Pacific, Straits of Juan de Fuca, Washington, U.S.A.

——— ——— ——— subspec. *pingue* Nicol, **57**, p. 177, pl. 29, figs. 1, 2. Recent, Pacific, Monterey Bay California. For: *Elphidium crispum* Schenck, 1940, Bull. Amer. Assoc. Petroleum Geologists, vol. 24, p. 1761, text fig. 4.

——— *subarcticum* Cushman, **26**, p. 27, pl. 3, figs. 34, 35. Recent Atlantic, off coast of New England.

EOANNULARIA gen. nov. Cole and Bermudez, **11**, p. 12. Fam. Planorbulinidae. Genotype: *Eoannularia eocenica* Cole and Bermudez, 1944, *ut infra*. Middle Eocene.

——— *eocenica* Cole and Bermudez, **11**, p. 12, pl. 1, figs. 11–16. Middle Eocene, Cuba.

EOCONULOIDES gen. nov. Cole and Bermudez, **11**, p. 10. Fam. Amphisteginidae. Genotype: *Eoconuloides wellsi* Cole and Bermudez, 1944, *ut infra*. Middle Eocene.

——— *wellsi* Cole and Bermudez, **11**, p. 11, pl. 1, figs. 4–10. Middle Eocene, Cuba.

EODICTYOCONUS gen. nov. Cole and Bermudez, **11**, p. 6. Fam. Valvulinidae. Genotype: *Pseudorbitolina cubensis* Cushman and Bermudez, 1936, Contr. Cushman Lab. Foram. Research, vol. 12, p. 59, pl. 10, figs. 27–30. Middle Eocene, Cuba.

Eoverbeekina americana Thompson and Miller, **70**, p. 492, pl. 80, figs. 3–6; pl. 83, figs. 3–7. Permian, southern Mexico.

Eponides duprêi Cushman and Schenck, 1928, var. *ciervoensis* Cushman and Simonson, **34**, p. 201, pl. 34, figs. 2, 3. Oligocene (or Upper Eocene ?), Tumey formation, California.

——— *ingramensis* Cushman and Goudkoff, **32**, p. 62, pl. 10, fig. 9. Upper Cretaceous, California.

Gaudryina (*Pseudogaudryina*) *jacksonensis* Cushman, 1926, var. *abnormis* Cushman and Renz, **33**, p. 78. New name for *Gaudryina* (*Pseudogaudryina*) *jacksonensis* Cushman var. *irregularis* Cushman and Renz, 1941, (non *Gaudryina irregularis* Hantken, 1876), Contr. Cushman Lab. Foram. Research, vol. 17, p. 6, pl. 1, figs. 11, 12. Upper Oligocene, Venezuela.

——— *rudita* Sandidge 1932, var. *diversa* Cushman and Goudkoff, **32**, p. 55, pl. 9, fig. 6. Upper Cretaceous, California.

Globigerina baroemoenensis LeRoy, 1939, var. *quadrata* LeRoy, **50**, p. 39, pl. 3, figs. 34, 35; pl. 7, figs. 37–39. Miocene, Central Sumatra. (Note: preoccupied by *Globigerina quadrata* White, 1928, Jour. Paleont., vol. 2, p. 195, pl. 27, fig. 18, from the Upper Cretaceous of eastern Mexico.)

——— *bulbosa* LeRoy, **50**, p. 39, pl. 3, figs. 26, 27. Miocene, Central Sumatra.

Globigerinoides sacculiferus (Brady, 1877) var. *irregularis* (for *irregularus*) LeRoy, **50**, p. 40, pl. 3, figs. 42, 43; pl. 6, figs. 45, 46. Miocene, Central Sumatra.

Globobulimina globosa LeRoy, **50**, p. 27, pl. 1, fig. 3; pl. 5, fig. 13. Miocene, Central Sumatra. (Note: also pictured from Miocene of western Java in LeRoy, 51, p. 85, pl. 2, fig. 1.)

Guttulina oregonensis Bandy, **3**, p. 370, pl. 60, fig. 14. Middle Eocene, Oregon.

——— *problema* d'Orbigny, 1826, var. *arcuata* Cushman, **27**, p. 9, pl. 1, fig. 7. Eocene, Wilcox, Bashi formation, Alabama.

Gyroidina condoni (Cushman and Schenck, 1928) var. *rotundiformis* Cushman and Simonson, **34**, p. 201, pl. 33, figs. 17–19. Oligocene (or Upper Eocene ?), Tumey formation, California.

——— *nassauensis* Cole, **10**, p. 53, pl. 2, fig. 12. Middle Eocene, Florida.

Haplophragmoides chapmani Crespin, **16**, p. 19,

pl. 1. figs. 2, 3. Lower Cretaceous, Northern New South Wales, Australia.

——— *colusaensis* Cushman and Goudkoff, **32**, p. 54, pl. 9, fig. 3. Upper Cretaceous, California.

——— *eggeri* Cushman, 1926, var. *minuta* Cushman and Goudkoff, **32**, p. 54, pl. 9, fig. 2. Upper Cretaceous, California.

——— *globosa* Lozo, **52**, p. 543, pl. 2, fig. 8; text fig. 16. Lower Cretaceous, Goodland formation, North Texas.

——— *trinitensis* Lozo, **52**, p. 544, pl. 1, fig. 8. Lower Cretaceous, Glen Rose formation, North Texas.

Hemicristellaria sumatrica LeRoy, **50**, p. 21, pl. 4, fig. 48; pl. 5, fig. 19. Miocene, Central Sumatra.

HEXAGONOCYCLINA gen. nov. Caudri, **9**, p. 12. Fam. Discocyclinidae. Genotype: *Orbitoclypeus ? cristensis* Vaughan, 1924, Bull. Geol. Soc. America, vol. 35, p. 814, pl. 36, fig. 8. Paleocene.

——— *meandrica* Caudri, **9**, p. 13, pl. 2, figs. 7, 9. Paleocene, Venezuela.

Hopkinsina pacifica Cushman, 1933, var. *atlantica* Cushman, **26**, p. 30, pl. 4, fig. 1. Recent, Atlantic, off coast of New England, 6 fathoms.

Lagena bifurcata LeRoy, **51**, p. 83, pl. 7, fig. 22. Miocene, West Java.

——— *gracillima* (Seguenza, 1862) var. *mollis* Cushman, **26**, p. 21, pl. 3, fig. 3. Recent, Atlantic, off coast of New England, 10–18 fathoms.

Lamarckina rugatina Bandy, **3**, p. 371, pl. 61, fig. 2. Middle Eocene, Oregon.

Lenticulina gunderbookaensis Crespin, **16**, p. 21, pl. 1, fig. 9. Lower Cretaceous, Northern New South Wales, Australia.

——— *warregoensis* Crespin, **16**, p. 21, pl. 1, fig. 8. Lower Cretaceous, Northern New South Wales.

Lingulina minuta Cushman, **19**, p. 38, pl. 6, fig. 10. Paleocene, Naheola formation, Alabama.

Lituola camerata Lozo, **52**, p. 544, pl. 1, figs. 4, 5; text fig. 17. Lower Cretaceous, Goodland formation, North Texas.

——— *inflata* Lozo, **52**, p. 547, pl. 1, fig. 1; text fig. 18. Lower Cretaceous, Kiamichi formation, North Texas.

Marginulina cocoaensis Cushman, 1925, var. *carapitana* Franklin, **41**, p. 310, pl. 46, fig. 8. Lower Oligocene, Carapita formation, Venezuela.

——— *curvisepta* Cushman and Goudkoff, **32**, p. 57, pl. 9, figs. 12, 13. Upper Cretaceous, California.

——— *indica* LeRoy, **51**, p. 78, pl. 2, figs. 8, 9. Miocene, West Java.

——— *subcretacea* Crespin, **16**, p. 21, pl. 1, fig. 10. Lower Cretaceous, Northern New South Wales, Australia.

——— *toulmini* Cushman, **19**, p. 34, pl. 5, fig. 16. Paleocene, Naheola formation, Alabama. For: *Vaginulinopsis brantlyi* Toulmin, 1941, (non *Hemicristellaria brantlyi* Garrett, 1941), Jour. Paleont., vol. 15, p. 583, pl. 79, figs. 8–10; and for *Marginulina sp.* Cushman, 1944, Contr. Cushman Lab. Foram. Research, vol. 20, p. 21, pl. 4, fig. 5.

Marginulinopsis cingulosa Bandy, **3**, p. 369, pl. 60, fig. 9. Middle Eocene, Oregon.

——— *prolata* Bandy, **3**, p. 369, pl. 60, fig. 10. Middle Eocene, Oregon.

Millerella pinguis Thompson, **69**, p. 425, pl. 1, figs. 18–20. Pennsylvanian, Kansas.

——— *pressa* Thompson, **69**, p. 423, pl. 2, figs. 16–23. Pennsylvanian, Kansas.

Millerella ? advena Thompson, **69**, p. 427, pl. 1, figs. 10–14. Pennsylvanian, Kansas.

——— *?* ——— var. *ampla* Thompson, **69**, p. 429, pl. 1, figs. 21, 22, (?)15. Pennsylvanian, Kansas.

Nodobaculariella multilocularis (Brady, Parker and Jones, 1888) var. *ornata* Cushman and Todd, **35**, p. 70, pl. 11, figs. 21, 22. Miocene, Florida. For: *Vertebralina multilocularis* Cushman and Ponton, 1932 (non Brady, Parker and Jones, 1888), Florida State Geol. Surv., Bull. 9, p. 57, pl. 8, figs. 2, 2.

——— *rudita* Cushman and Todd, **35**, p. 73, pl. 12, fig. 6. Recent, Pacific, off Palawan, Philippine Islands.

——— *rustica* Cushman and Todd, **35**, p. 73, pl. 12, figs. 4, 5. Pacific, Recent. off Romblon, Philippine Islands.

Nodophthalmidium simplex Cushman and Todd, **35**, p. 67, pl. 11, fig. 8. Recent, Malay Archipelago. For: *Nubecularia tibia* Millett, 1898, (non Jones and Parker, 1860), Jour. Roy. Micr. Soc., p. 261, pl. 5, fig. 3; for: *Nubecularia tibia* Rhumbler, 1906, (non Jones and Parker, 1860), Zool. Jahrb. Abt. System., vol. 24, p. 38, pl. 2, fig. 13; and for: *Nodobacularia tibia* Cushman, 1917 (non Jones and Parker, 1860), U. S. Nat. Mus., Bull. 71, pt. 6, p. 39, pl. 8, figs. 1 and ? 2.

Nodosaria acuminata Hantken, 1875, var. *uniforminata* LeRoy, **51**, p. 80, pl. 1, fig. 21. Miocene, West Java.

——— *graysonensis* Tappan, **66**, p. 560, New name for: *Nodosaria bifurcata* Tappan, 1940, (non *Nodosaria* (*Dentalina*) *bifurcata* d'Orbigny, 1846), Jour. Paleont., vol. 14, p. 103, pl. 16, fig. 5. Lower Cretaceous, Texas.

——— *macneili* Cushman, **19**, p. 37, pl. 6, fig. 9. Paleocene, Naheola formation, Alabama. For: *Nodosaria paupercula* Toulmin, 1941 (non Reuss, 1845), Jour. Paleont., vol. 15, p. 588, pl. 79, figs. 29, 30.

——— *spinocostata* Cooper, **12**, p. 349, pl. 54, fig. 11. Paleocene, Porters Creek formation, Illinois. For: *Nodosaria spinulosa* Plummer, *pro parte* (non Costa, 1855), Univ. Texas Bull. 2644, 1927, p. 84, pl. 4, fig. 19 c only; and for *Ellipsonodosaria alexanderi* Cushman, 1940 (*pro parte*), Contr. Cushman Lab. Foram. Research, vol. 16, p. 69, pl. 11, figs. 27 and 29 only. (Note: *cave Nodosaria spinicosta* d'Orbigny, 1846, and *Nodosaria hochstetteri* Schwager var. *spinicosta* Koch, 1923.)

Nonion browni Cole, **10**, p. 37, pl. 3, fig. 5. Oligocene, Florida. (Note: Preoccupied by d'Orbigny, 1839, in De la Sagra, Hist. Phys. Pol. Nat. Cuba, vol. 8, Foraminiferes, pl. 7, figs. 22, 23, Recent, Cuba and Jamaica.)

——— *microumbilicatus* LeRoy, **50**, p. 23, pl. 4, figs. 26, 27. Miocene, Central Sumatra.
——— *pauciloculum* Cushman, **26**, p. 24, pl. 3, fig. 25. Recent, Atlantic, off coast of New England, 3½ fathoms.

Operculinoides gravelli Cole, **10**, p. 44, pl. 1, fig. 3; pl. 5, fig. 13; pl. 7, figs. 1, 3, 10, 12, 19. Middle Eocene, Florida.
——— *nassauensis* Cole, **10**, p. 47, pl. 1, fig. 6; pl. 5, figs. 2, 3, 10–12, 14, 16; pl. 7, fig. 8; pl. 8, figs. 9–11; pl. 18, figs. 2, 3. Oligocene, Florida.

Parafusulina australis Miller and Thompson, **70**, p. 503, pl. 81, figs. 2–9. Permian, southern Mexico.
Paraschwagerina roveloi Thompson and Miller, **70**, p. 500, pl. 80, figs. 1, 2; pl. 82, figs. 5, 6. Permian, Southern Mexico.
Parrella macneili Cushman, **19**, p. 47, pl. 7, figs. 30, 31. Paleocene, Naheola formation, Alabama.
Planularia toddae Cushman, **19**, p. 34, pl. 5, fig. 12. Paleocene, Naheola formation, Alabama. For: *Astacolus jugleri* Toulmin, 1941 (non Reuss, 1851), Jour. Paleont., vol. 15, p. 580, pl. 78, figs. 27, 28; and for: *Planularia sp.* Cushman and Todd, 1942, Contr. Cushman Lab. Foram. Research, vol. 18, p. 27, pl. 5, fig. 8.
——— *tolmani* Cushman and Simonson, **34**, p. 195, pl. 30, figs. 13, 14. Oligocene (or Upper Eocene ?) Tumey formation, California.
Planulina cretacea Crespin, **16**, p. 22, pl. 1, figs. 11, 12. Lower Cretaceous, Northern New South Wales, Australia.
——— *mera* Cushman, **26**, p. 36, pl. 4, fig. 25. Recent, Atlantic, off coast of New England, 10–13 fathoms.
Plectofrondicularia packardi Cushman and Schenck, 1928, var. *multilineata* Cushman and Simonson, **34**, p. 197, pl. 32, figs. 2–4. Oligocene (or Upper Eocene ?), Tumey formation, California.
Polydiexodina mexicana Dunbar, **38**, p. 47, pl. 16, figs. 7–9. Uppermost Permian, Coahuila, Mexico.
POROARTICULINA gen. nov. Cushman, **20**, p. 52. Fam. Miliolidae. Genotype: *Poroarticulina glabra* Cushman, 1944, *ut infra*. Miocene.
——— *glabra* Cushman, **20**, p. 52, pl. 8, figs. 19–22. Miocene, Roumania.
POROEPONIDES gen. nov. Cushman, **26**, p. 34. Fam. Rotaliidae. Genotype: *Rosalina lateralis* Terquem, 1878, Soc. géol. France, Mém., (3), vol. 1, no. 3, p. 25, pl. 2, fig. 11, Upper Pliocene, Isles of Rhodes. (Note: for further reference to generotype see Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 47.) Pliocene, and Recent.
Proporocyclina see *Pseudophragmina*.
Proteonina atlantica Cushman, **26**, p. 5, pl. 1, fig. 4. Recent, Atlantic, off coast of New England, 13 fathoms.
Pseudoglandulina costulata Cushman, **23**, p. 88, pl. 13, fig. 10. Upper Cretaceous, Mississippi.
Pseudophragmina (*Proporocyclina*) *cedarkeysensis* Cole, **10**, p. 81, pl. 2, fig. 13; pl. 18, fig. 9; pl. 26, figs. 1–4; pl. 27, figs. 1, 2. Middle Eocene, Salt Mountain Limestone, Florida. For: *Pseudophragmina* (*Proporocyclina*) *zaragosensis* Cole, 1942 (non *Discocyclina zaragosensis* Vaughan, 1929), Florida State Geol. Surv. Bull. 20, p. 46, pl. 13, figs. 1–5; pl. 14, figs. 1–5.
——— (———) *hannai* Cole, **10**, p. 84, pl. 1, fig. 12; pl. 8, figs. 7, 17; pl. 12, figs. 7–11; pl. 18, figs. 5, 6; pl. 26, fig. 5; pl. 27, fig. 3; pl. 28, figs. 1, 2. Middle Eocene, Florida.
Pulvinulinella hardyana LeRoy, **50**, p. 37, pl. 2, figs. 28–30. Miocene, Central Sumatra.

Quinqueloculina alabamensis Cushman, **19**, p. 30, pl. 5, fig. 3. Paleocene, Naheola formation, Alabama.
——— *pulcherrima* Cushman, **19**, p. 30, pl. 5 fig. 5. Paleocene, Naheola formation, Alabama.
——— *seminula* (Linné, 1758) var. *jugosa* Cushman, **26**, p. 13, pl. 2, fig. 15. Recent, Atlantic, off coast of New England.

RANIKOTHALIA gen. nov. Caudri, **9**, p. 17. Fam. Camerinidae (?). Genotype: *Nummulites nuttalli* Davies, 1927, Quart. Jour. Geol. Soc. London, vol. 83, p. 266, pl. 18, figs. 1, 3, 4; pl. 19, figs. 7–9. Pre-Ypresian beds of Sind, British India. Paleocene.
RAUSERELLA gen. nov. Dunbar, **38**, p. 37. Fam. Fusulinidae. Genotype: *Rauserella erratica* Dunbar, 1944, *ut infra*. High Permian, Mexico, Texas, Japan.
——— *erratica* Dunbar, **38**, p. 37, pl. 9, figs. 1–8. Uppermost Permian, southwestern Coahuila, Mexico.
Rectobolivina multicostata LeRoy, **51**, p. 85, pl. 2, figs. 32, 33; pl. 1, figs. 11, 12.
Reussella californica Cushman and Goudkoff, **32**, p. 59, pl. 10, figs. 3–5. Upper Cretaceous, California.
Robulus alabamensis Cushman, **19**, p. 33, pl. 5, fig. 13. Paleocene, Naheola formation, Alabama.
——— *pseudolimbosus* LeRoy, **50**, p. 17, pl. 4, figs. 1, 2; pl. 7, figs. 46, 47. Miocene, Central Sumatra.
Rotalia multicamerata LeRoy, **50**, p. 35, pl. 7, figs. 22–24. Miocene, Central Sumatra.
——— *sumatrana* LeRoy, **50**, p. 35, pl. 2, figs. 34–36. Miocene, Central Sumatra.
——— *umbonata* LeRoy, **50**, p. 35, pl. 7, figs. 16–18. Miocene, Central Sumatra. (Note: preoccupied by *Rotalia soldanii* d'Orbigny, 1826, var *umbonata* Silvestri, 1898, Mem. Accad. Pont. Nuovi Lincei, (2), vol. 15, p. 329.)
ROTORBINELLA gen. nov., Bandy, **3**, p. 372. Fam. Rotaliidae; Subfam. Discorbisinae. Genotype: *Rotorbinella colliculus* Bandy, 1944, *ut infra*. Eocene to Recent.
——— *colliculus* Bandy, **3**, p. 372, pl. 61, fig. 6. Middle Eocene, Oregon.

Saracenaria blancoensis Bandy, **3**, p. 368, pl. 60, fig. 8. Middle Eocene, Oregon.
——— *italica* Defrance, 1824, var. *carapitana* Franklin, **41**, p. 312, pl. 45, fig. 14. Lower Oligocene, Carapita formation, Venezuela.

Schubertella müllerriedi Thompson and Miller, **70**, p. 488, pl. 79, figs. 5–11. Permian, South Mexico.
Schwagerina chiapasensis Thompson and Miller, **70**, p. 494, pl. 83, figs. 1, 2; pl. 84, figs. 1–3. Permian, South Mexico.
——— *figueroai* Thompson and Miller, **70**, p. 496, pl. 82, figs. 1–4. Permian, South Mexico.
——— *gruperaensis* Thompson and Miller, **70**, p. 495, pl. 79, figs. 1–4. Permian, South Mexico.
Siphogenerina simplex LeRoy, **51**, p. 87, pl. 2, figs. 30, 31. Miocene, West Java.
Siphogenerinoides clarki Cushman and Campbell, 1936, var. *costifera* Cushman and Goudkoff, **32**, p. 58, pl. 9, fig. 19. Upper Cretaceous, California.
Siphonina indica LeRoy, **50**, p. 36, pl. 3, figs. 18–20. Miocene, Central Sumatra.
——— *nassauensis* Cole, **10**, p. 54, pl. Oligocene, Florida.
Sphaeroidinella multiloba LeRoy, **51**, p. 91, pl. 4, figs. 7–9. Miocene. West Java.
Spiroloculina alabamensis Cushman, **19**, p. 31, pl. 5, fig. 8. Paleocene, Naheola formation, Alabama.
——— *alabastra* Cushman and Ellisor, **31**, p. 50, pl. 8, figs. 11–13. Middle Oligocene, Texas.
——— *albatrossi* Cushman and Todd, **37**, p. 63, pl. 8, fig. 29. Recent, Indopacific, 139 fathoms, off Goto Island, Eastern Sea.
——— *alticostata* Cushman and Todd, **37**, p. 39, pl. 6, fig. 12. Pliocene, Sicily, Italy.
——— *alveata* Cushman and Todd, **37**, p. 28, pl. 4, figs. 29, 30. Miocene, Bowden formation, Jamaica. (Note: Consult original publication for synonymy).
——— *aperta* Cushman and Todd, **37**, p. 66, pl. 9, figs. 21, 22. Recent, Indopacific, Samoa, 25 fathoms. (Note: Consult original publication for synonymy).
——— *attenuata* Cushman and Todd, **37**, p. 67, pl. 9, figs. 23–25. Recent, Indopacific, Samoa, 13 fathoms. For: *Spiroloculina grateloupi* Cushman, 1924 (non d'Orbigny, 1826), Publ. 342, Carnegie Inst. Washington, p. 54, pl. 20, figs. 3, 4.
——— *communis* Cushman and Todd, **37**, p. 63, pl. 9, figs. 4, 5, 6, 8. Recent, Indopacific, off Philippine Islands, 50 fathoms. (Note: Consult original publication for synonymy).
——— ——— ——— ——— var. *excisa* Cushman and Todd, **37**, p. 65, pl. 9, figs. 15–17. Recent, Indopacific, off Philippine Islands, 19 fathoms. For: *Spiroloculina grateloupi* Cushman, 1921, (non d'Orbigny, 1826) U. S. Nat. Mus. Bull. 100, vol. 4, p. 396, pl. 78, fig. 4; pl. 100, fig. 3; text figs. 17, 18.
——— ——— ——— ——— var. *polita* Cushman and Todd, **37**, p. 65, pl. 9, fig. 14. Recent, Indopacific, off Philippine Islands, 50 fathoms.
——— *corrugata* Cushman and Todd, **37**, p. 61, pl. 8, figs. 22–25. Recent, Indopacific, off Philippine Islands, 20 fathoms. (Note: for synonymy consult original publication).
——— *dentata* Cushman and Todd, **37**, p. 71, pl. 9, figs. 33, 34. Recent, Pacific, off Lower California coast. For: *Spiroloculina planulata* Cushman and Valentine, 1930, (non Lamarck), Contr. Dept. Geol. Stanford Univ., vol. 1, no 1, p. 15, pl. 4, fig. 3.
——— *depressa* d'Orbigny, 1826, var. *californica* Cushman and Todd, **37**, p. 30, pl. 5, figs. 10–12. Recent, Pacific, off Channel Islands, southern California. For: *Spiroloculina depressa* d'Orb. in Cushman and Valentine, 1930, Contr. Dept. Geol. Stanford Univ., vol. 1, no. 1, p. 14, pl. 4, fig. 1.
——— *indica* Cushman and Todd, **37**, p. 71, pl. 9, fig. 32. Recent, shore sands, Karachi, British India.
——— *jarvisi* Cushman and Todd, **37**, p. 14, pl. 3, fig. 9. Upper Eocene, Trinidad, B.W.I.
——— *jucunda* Cushman and Ellisor, **31**, p. 51, pl. 8, figs. 16–18. Middle Oligocene, Texas.
——— *laevigata* Cushman and Todd, **37**, p. 67, pl. 9, figs. 26–29. Recent, shore sands, northern coast of Java. (Note: For synonymy consult original publication).
——— *lucida* Cushman and Todd, **37**, p. 70, pl. 9, figs. 30, 31. Recent, shore sands, northern coast of Java.
——— *manifesta* Cushman and Todd, **37**, p. 62, pl. 8, figs. 26–28. Recent, Indopacific, off Nagubat Island, Mindanao, Philippine Islands, 44 fathoms. (Note: Consult original publication for synonymy).
——— *norvegica* Cushman and Todd, **37**, p. 43, pl. 6, figs. 19, 27. Recent, Atlantic, Croquer Island anchorage, Norway, 10 fathoms. (Note: Consult original publication for synonymy).
——— *novo-zealandica* Cushman and Todd, **37**, p. 27, pl. 4, fig. 23. Tertiary (Miocene), New Zealand. For: *Spiroloculina rotundata* Kreuzberg, 1931, (non Williamson, 1858), N. Jahrb. f. Min. etc., Beil-Bd. 64, Abt. B, p. 276, pl. 20, fig. 2. (new name.)
——— *obscura* Cushman and Todd, **37**, p. 20, pl. 1, fig. 8; pl. 3, figs. 22–25. Miocene, France. (For synonymy consult original publication). (new name).
——— *profunda* Cushman and Todd, **37**, p. 38, pl. 6, fig. 14. Pliocene, Florida. (Note: For synonymy consult original publication.)
——— *regularis* Cushman and Todd, **37**, p. 51, pl. 7, figs. 26, 27. Recent, Indopacific, off Philippine Islands, 312 fathoms. New name for: *Spiroloculina circularis* Cushman, 1921 (non Chapman, 1915), U. S. Nat. Mus., Bull. 100, vol. 4, p. 403, pl. 80, figs. 1, 2; and for same reference in LeRoy, 1941, Colorado School of Mines, Quart., vol. 36, p. 72, pl. 2, figs. 19, 20.
——— *rugosa* Cushman and Todd, **37**, p. 66, pl. 9, figs. 9–13. Recent, Indopacific, Apia Harbor, Upolu, Samoa.
——— ——— ——— ——— var. *curvatura* Cushman and Todd, **37**, p. 66, pl. 9, figs. 18–20. Recent, Indopacific, Apia Harbor, Upolu, Samoa.
——— *scita* Cushman and Todd, **37**, p. 60, pl. i, fig. 14; pl. 8, figs. 20, 21. Recent, Indopacific, Pago Pago Harbor, Samoa. New name. (Note: for synonymy see original publication).

——— *spissa* Cushman and Todd, **37**, p. 19, pl. 3, figs. 18–21. Lower Oligocene, Byram marl, Mississippi. For: *Spiroloculina grateloupi* Cushman, 1922 (non d'Orbigny, 1826), U. S. Geol. Surv., Prof. Pap. 129-E, p. 101, pl. 25, fig. 2.

——— *texana* Cushman and Ellisor, **31**, p. 51, pl. 8, figs. 14, 15. Middle Oligocene, Texas. For: *Spiroloculina aff. depressa* d'Orbigny in Nuttall, 1932. Jour. Paleont., vol. 6, p. 8, pl. 1, fig. 3.

——— *tricosta* Cushman and Todd, **37**, p. 21, pl. 1, fig. 9; pl. 3, figs. 26–29. Miocene, France. New name for: *Spiroloculina tricarinata* d'Orbigny, 1826 (non Terquem, 1882) Ann. Sci. Nat., vol. 7, p. 298; figured in Fornasini, 1904, Mem. Accad. Sci. Ist. Bologna, (6), vol. 1, p. 4, pl. 1, fig. 4. (d'Orbigny's original figure).

——— *venusta* Cushman and Todd, **37**, p. 60, pl. 8, figs. 16, 17. Recent, Indopacific, Caroline Islands. For: *Spiroloculina caduca* Cushman, 1932 (non Cushman, 1922) Bull. 161, U. S. Nat. Mus., pt. 1, p. 39, pl. 9, figs. 11, 12.

Spiroplectammina cushmani Crespin, **16**, p. 19, pl. 1, fig. 7. Lower Cretaceous, Northern New South Wales, Australia.

Staffella centralis Thompson and Miller, **70**, p. 491, pl. 80, figs. 7–11. Permian, southern Mexico.

——— *subacuta* Dunbar, **38**, p. 39, pl. 10, figs. 8–15; pl. 11, fig. 1. Permian, Coahuila, Mexico.

Textularia midwayana Lalicker, 1935, var *pansa*, Cushman, **19**, p. 30, pl. 5, fig. 2. Paleocene, Naheola formation, Alabama.

——— *vantuyli* LeRoy, **50**, p. 15, pl. 8, figs. 54, 55. Miocene, Central Sumatra.

Triloculina alabamensis Cushman, **19**, p. 32, pl. 5, fig. 11. Paleocene, Naheola formation, Alabama.

——— *brevidentata* Cushman, **26**, p. 16, pl. 2, fig. 25. Recent, shore sands, Massachusetts.

——— *concisa* Cushman, **26**, p. 16, pl. 2, fig. 24. Recent, shore sands, Rhode Island.

——— *natchitochensis* Howe, 1939, var. *deca* Cushman, **19**, p. 32, pl. 5, figs. 9, 10. Paleocene, Naheola formation, Alabama.

Tritaxilina suturanodosa LeRoy, **50**, p. 16, pl. 1, figs. 60, 61; pl. 5, figs. 1, 2. Miocene, Central Sumatra.

Triticites piloncillosensis Dunbar, **38**, p. 40, pl. 10, figs. 1–7. Probably Pennsylvanian, or Permian, Coahuila, Mexico.

Trochammina depressa Lozo, **52**, p. 552, pi. 2, figs. 4, 5. Lower Cretaceous, North Texas.

——— *howei* Cushman, **18**, p. 20, pl. 3, fig. 28. Lower Eocene, Wilcox, Virginia.

——— *lobata* Cushman, **26**, p. 18, pl. 2, fig. 10. Recent, Atlantic, off coast of New England, 2–18 fathoms.

——— *parvula* Crespin, **16**, p. 20, pl. 1, fig. 6. Lower Cretaceous, Northern New South Wales, Australia. (Note: *cave Trochammina parva* Cushman and Laiming, 1931.)

——— *propria* Cushman, **26**, p. 19, pl. 2, fig. 11. Recent, Atlantic, off coast of New England, 10 fathoms.

——— *raggatti* Crespin, **16**, p. 20, pl. 1, figs. 4, 5. Lower Cretaceous, Northern New South Wales, Australia.

Uvigerina atwilli Cushman and Simonson, **34**, p. 200, pl. 33, figs. 2–4. Oligocene (or Upper Eocene?) Tumey formation, California.

——— *canariensis* d'Orbigny, 1839, var. *nuttalliana* Franklin, **41**, p. 314, pl. 46, fig. 22. Lower Oligocene, Carapita formation, Venezuela. For: *Uvigerina canariensis* Nuttall, 1932, (non d'Orbigny, 1839), Jour. Paleont., vol. 6, p. 22, pl. 5, fig. 9; and for *Uvigerina carapitana* Hedberg, 1937, Jour. Paleont., vol. 11, p. 677, pl. 91, fig. 20. (Note: preoccupied by *Uvigerina gardnerae* Cushman, 1926, var. *nuttalliana* Howe and Wallace, 1932, Louisiana Geol. Survey Bull. No. 2, p. 64.)

——— *interrupta-costata* LeRoy, **50**, p. 31, pl. 5, fig. 28. Miocene, Central Sumatra.

——— *nomlandi* LeRoy, **50**, p. 32, pl. 1, fig. 47. Miocene, Central Sumatra.

——— *sparsicostata* LeRoy, **50**, p. 31, pl. 1, figs. 45, 46; pl. 5, fig. 25. Miocene, Central Sumatra.

——— *uniserialis* LeRoy, **50**, p. 32, pl. 8, fig. 43. Miocene, Central Sumatra.

Vaginulina plumoides Plummer, 1926, var. *virginiana* Cushman, **18**, p. 22, pl. 4, fig. 5. Lower Eocene, Wilcox, Virginia.

Valvulineria javana LeRoy, **51**, p. 88, pl. 7, figs. 4–6. Miocene, West Java.

——— *lillisi* Cushman and Goudkoff, **32**, p. 61, pl. 10, fig. 8. Upper Cretaceous, California.

——— *orolomaensis* Cushman and Goudkoff, **32**, p. 60, pl. 10, fig. 7. Upper Cretaceous, California.

——— *patelliformis* Bandy, **3**, p. 361, pl. 61, fig. 5. Middle Eocene, Oregon.

——— *thomasi* Cushman and Simonson, **34**, p. 201, pl. 33, figs. 15, 16. Oligocene (or Upper Eocene?), Tumey formation, California.

——— *tumeyensis* Cushman and Simonson, **34**, p. 201, pl. 33, figs. 13, 14. Oligocene, or Upper Eocene?), Tumey formation, California.

Virgulina alabamensis Cushman, **19**, p. 43, pl. 7, fig. 13. Paleocene, Naheola formation, Alabama. (Note: Preoccupied by Cushman and MacGlamery, 1939, Contr. Cushman Lab. Foram. Research, vol. 15, p. 48, pl. 9, fig. 7, this species was renamed: *Virgulina naheolensis* by Cushman, 1944, *ut infra.*)

——— *naheolensis* Cushman, **21**, p. 78. New name for *Virgulina alabamensis* Cushman, 1944, *ut supra*, non *Virgulina alabamensis* Cushman and MacGlamery, 1939, Cushman Lab. Foram. Research, Contr., vol. 15, p. 48, pl. 9, fig. 7.

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Amphicoryne sp. LeRoy, **51**, p. 81, pl. 7, figs. 18, 19. Miocene, Java.

Amphimorphina (?) sp. Cushman and Goudkoff, **32**, p. 58, pl. 9, figs. 15, 16. Upper Cretaceous, California.
Anomalina sp. A LeRoy, **50**, p. 41, pl. 6, figs. 4–6, 13–15. Miocene, Sumatra.
Bolivina sp. LeRoy, **51**, p. 81, pl. 1, figs. 30, 31. Miocene, Java.
——— *sp. A* LeRoy, **50**, p. 27, pl. 8, figs. 27, 28. Miocene, Sumatra.
——— *sp. B* Leroy, **50**, p. 27, pl. 8, figs. 23, 24. Miocene, Sumatra.
——— *sp. C* LeRoy, **50**, p. 27, pl. 5, figs. 5, 6. Miocene, Sumatra.
——— *sp. D* LeRoy, **50**, p. 28, pl. 8, figs. 19, 20. Miocene, Sumatra.
Bifarina sp. A LeRoy, **50**, p. 30, pl. 5, fig. 26. Miocene, Sumatra.
Bulimina sp. A LeRoy, **50**, p. 25, pl. 1, fig. 6. Miocene, Sumatra.
——— *sp. B* LeRoy, **50**, p. 25, pl. 1, fig. 7. Miocene, Sumatra.
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Cibicides sp. LeRoy, **51**, p. 92, pl. 6, figs. 1–3. Miocene, Java.
——— *sp. A* LeRoy, **50**, p. 43, pl. 7, figs. 7–9. Miocene, Sumatra.
Cribrostomoides (?) sp. Cushman and Goudkoff, **32**, p. 55, pl. 9, fig. 5. Upper Cretaceous, California.
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——— *sp. A* LeRoy, **50**, p. 18, pl. 8, fig. 7. Miocene, Sumatra.
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——— *? sp. B* Cushman and Simonson, **34**, p. 200, pl. 33, figs. 8, 9. Oligocene or Upper Eocene, California.
——— *? sp. C* Cushman and Simonson, **34**, p. 200, pl. 33, fig. 10. Oligocene or Upper Eocene, California.
——— *? sp. D* Cushman and Simonson, **34**, p. 201, pl. 33, fig. 11. Oligocene or Upper Eocene, California.
——— *? sp. E* Cushman and Simonson, **34**, p. 201, pl. 33, fig. 12. Oligocene or Upper Eocene, California.
Epistomina sp. LeRoy, **51**, p. 89, pl. 4, figs. 4–6. Miocene, Java.
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Guttulina sp. A LeRoy, **50**, p. 23, pl. 1, fig. 52. Miocene, Sumatra.
Gyroidina sp. A LeRoy, **50**, p. 34, pl. 3, figs. 13, 14. Miocene, Sumatra.
Haplophragmoides sp. Cushman, **18**, p. 19, pl. 3, fig. 23. Eocene, Virginia.
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——— *sp. B* LeRoy, **50**, p. 22, pl. 1, fig. 13. Miocene, Sumatra.
——— *sp. C* LeRoy, **50**, p. 22, pl. 8, fig. 17. Miocene, Sumatra.
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——— *sp.* Cushman, **17**, p. 6, pl. 1, fig. 23. Upper Cretaceous, Texas.
——— *sp.* Cushman, **27**, p. 8, pl. 1, fig. 4. Eocene, Alabama.
——— *sp.* Cushman and Simonson, **34**, p. 196, pl. 30, fig. 15. Oligocene or Upper Eocene, California.
——— *sp.* Cushman and Simonson, **34**, p. 196, pl. 31, figs. 1–4. Oligocene or Upper Eocene, California.
——— *sp.* LeRoy, **51**, p. 78, pl. 2, fig. 10. Miocene, Java.
——— *sp. A* LeRoy, **50**, p. 18, pl. 1, fig. 53. Miocene, Sumatra.
——— *sp. B* LeRoy, **50**, p. 18, pl. 5, fig. 17. Miocene, Sumatra.
Nankinella ? sp. Thompson and Miller, **70**, p. 489, pl. 80, figs. 12, 13. Permian, Mexico.
Nodosaria sp. A LeRoy, **50**, p. 19, pl. 8, fig. 2. Miocene, Sumatra.
——— *sp. A* Franklin, **41**, p. 311, pl. 46, fig. 3. Lower Oligocene, Venezuela.
——— *sp. B* Franklin, **41**, p. 312, pl. 45, fig. 18. Lower Oligocene, Venezuela.
——— *sp. B* LeRoy, **50**, p. 19, pl. 8, fig. 6. Miocene, Sumatra.
——— *sp. C* LeRoy, **50**, p. 19, pl. 8, fig. 9. Miocene, Sumatra.
——— *sp. D* LeRoy, **50**, p. 19, pl. 8, fig. 10. Miocene, Sumatra.
Nonionella sp. Cushman and Simonson, **34**, p. 196, pl. 31, fig. 15. Eocene-Oligocene, California.
Patellina sp. Cushman, **19**, p. 45, pl. 7, fig. 22. Paleocene, Alabama.
Planularia sp. Cushman and Goudkoff, **32**, p. 56, pl. 9, fig. 10. Upper Cretaceous, California.
——— *sp.* Cushman and Simonson, **34**, p. 195, pl. 30, fig. 16. Oligocene or Upper Eocene, California.
Planulina sp. Cushman and Simonson, **34**, p. 202, pl. 34, fig. 13. Oligocene or Upper Eocene, California.
Plectofrondicularia sp. A LeRoy, **50**, p. 25, pl. 8, fig. 16. Miocene, Sumatra.
——— *sp.* Cushman and Simonson, **34**, p. 197, pl. 32, fig. 5. Eocene-Oligocene, California.
Polymorphina sp. Cushman, **27**, p. 9, pl. 1, fig. 11. Eocene, Alabama.
Polymorphinella sp. Cushman, **19**, p. 41, pl. 7, fig. 6. Paleocene, Alabama.

Pseudoglandulina sp. Cushman and Simonson, **34**, p. 196, pl. 31, fig. 13. Oligocene or Upper Eocene, California.

Pseudorbitoides ? sp. Cole, **10**, p. 56, pl. 2, figs. 4, 9, 10; pl. 21, fig. 12. Probably Upper Cretaceous, Florida.

Pyrulina sp. Cushman, **18**, p. 23, pl. 4, fig. 16. Lower Eocene, Virginia.

Quinqueloculina sp. H LeRoy, **50**, p. 16, pl. 6, figs. 25–27. Miocene, Sumatra.

Rectobolivina sp. A LeRoy, **50**, p. 31, pl. 8, fig. 14. Miocene, Sumatra.

Reophax sp. Cushman, **18**, p. 19, pl. 3, fig. 22. Eocene, Virginia.

——— *? sp.* Cushman, **26**, p. 10, pl. 1, fig. 20. Recent, Atlantic, 18 fathoms.

Robulus sp. Cushman, **27**, p. 8, pl. 1, fig. 3. Eocene, Alabama.

——— *sp.* Cushman, **18**, p. 21, pl. 4, fig. 2. Lower Eocene, Virginia.

——— *sp.* LeRoy, **51**, p. 77, pl. 3, fig. 5, 6. Miocene, Java.

——— *sp.* LeRoy, **51**, p. 78, pl. 3, figs. 9, 10. Miocene, Java.

——— *sp.* LeRoy, **51**, p. 78, pl. 3, figs. 11, 12. Miocene, Java.

——— *sp.* LeRoy, **51**, p. 78, pl. 3, figs. 13, 14. Miocene, Java.

——— *sp. B* LeRoy, **50**, p. 16, pl. 4, figs. 9, 10. Miocene, Sumatra.

——— *sp. E* LeRoy, **50**, p. 17, pl. 4, figs. 5, 6. Miocene, Sumatra.

——— *sp. F* LeRoy, **50**, p. 17, pl. 4, figs. 19, 20. Miocene, Sumatra.

——— *sp. G* LeRoy, **50**, p. 17, pl. 5, figs. 43, 44. Miocene, Sumatra.

——— *sp. H* LeRoy, **50**, p. 17, pl. 5, figs. 45, 46. Miocene, Sumatra.

——— *sp. J* LeRoy, **50**, p. 17, pl. 4, fig. 21. Miocene, Sumatra.

Rotalia sp. A LeRoy, **50**, p. 34, pl. 7, figs. 13–15. Miocene, Sumatra.

——— *sp. B* LeRoy, **50**, p. 34, pl. 7, figs. 19–21. Miocene, Sumatra.

Schwagerina sp. A Thompson and Miller, **70**, p. 497, pl. 79, fig. 12. Permian, Mexico.

——— *sp. B* Thompson and Miller, **70**, p. 498, pl. 81, fig. 1. Permian, Mexico.

——— *sp. C* Thompson and Miller, **70**, p. 499, pl. 79, fig. 13. Permian, Mexico.

Stichocibicides sp. Cushman, **18**, p. 28, pl. 4, fig. 31. Lower Eocene, Virginia.

Textularia ? sp. Cushman and Simonson, **34**, p. 193, pl. 30, fig. 3. Oligocene or Upper Eocene, California.

NOMINA NUDA

In publication No. **1**, E. R. Applin and L. Jordan presented figures of several new species without descriptions. These forms, cited below, are regarded as *nomina nuda*, although they were duly described and figured in 1945 by their authors in a paper entitled "Diagnostic Foraminifera from subsurface formations in Florida" (Jour. Paleontology, vol. 19, 1945, pp. 129–148, pls. 18–21, 2 text figs.) The list of the *nomina nuda* is, as follows:

Amphistegina alabamensis, Amphistegina pinarensis Cushman and Bermudez var. *lawsoni, Anomalina rubiginosa* Cushman var. *cosdeni, Archaias columbiaensis, Asterigerina subacuta,* Cushman var. *floridensis, Cyclammina watersi, Flintina avonparkensis, Haplophragmoides ? bushnellensis, Lockhartia ? sp., Miscellanea n. sp., Quinqueloculina leonensis, Spiroloculina seminolensis, Sulcoperculina cosdeni, Valvulammina nassauensis,* and *Valvulina cushmani.*

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 2, PP. 184–185, MARCH 1946

PALEONTOLOGICAL NOTES

PUBLICATIONS ON FORAMINIFERA ISSUED DURING THE YEARS 1940–1945 IN THE NETHERLANDS.

A. TEN DAM
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I

Issued from the Micropaleontological Laboratory of the State Geological Survey of the Netherlands.

1. A. TEN DAM and TH. REINHOLD, The Genus Darbyella and its species, Geol. & Mijnbouw, T. 3, no. 4, pp. 108–111, 2 pl., 1941.
2. A. TEN DAM and TH. REINHOLD, Ein Vorkommen von Pernerina depressa im Hervien der Niederlande, Geol. & Mijnbouw, T. 3, no. 5, pp. 157–159, 1 pl., 1941.
3. A. TEN DAM and TH. REINHOLD, Nonioninidae as Tertiary index Foraminifera, Geol. & Mijnbouw, T. 3, no. 6, pp. 209–212, 2 pl., 1941.
4. A. TEN DAM and TH. REINHOLD, Asterigerinen als Indexforaminiferen fuer des Nordwest-Europäische Tertiaer, Geol. & Mijnbouw, T. 3, no. 7, pp. 220–223, 1 pl., 1941.
5. A. TEN DAM and TH. REINHOLD, Trimorphie bei einer *Uvigerina*, Geol. & Mijnbouw, T. 3, no. 8, pp. 237–240, 2 pl., 1941.
6. A. TEN DAM and TH. REINHOLD, Some Foraminifera from the Lower Liassic and the Lower Oolitic of the Eastern Netherlands, Geol. & Mijnbouw, T. 4, no. 1, pp. 8–11, 2 pl., 1942.
7. A. TEN DAM and TH. REINHOLD, Die stratigraphische Gliederung des niederländischen Plio-Plistozäns nach Foraminiferen, Med. Geol. Stichting, Serie C. V. no. 1, pp. 1–65, 6 pl., 5 tab., 1941.
8. A. TEN DAM and TH. REINHOLD, Die stratigraphische Gliederung des niederländischen Oligo-Miozäns nach Foraminiferen, Med. Geol. Stichting, Serie C. V. no. 2, pp. 1–106, 10 pl., 8 tab., 1942.
9. A. TEN DAM, Overzicht over de foraminiferenfaunae van het tertiair in Nederland, Hand. Ned. Nat. Gen. Congres, pp. 317–318, 1943.
10. A. TEN DAM, Facies in het nederlandsche Mesozoicum en Kaenozoicum op grond van de microfauna, Versl. Bijeenk. Micropal., no. 1, Sept. 1943, pp. 1–2.
11. A. TEN DAM, Methoden voor faciesanalyse met foraminiferen, Versl. Bijeenk. Micropal., no. 2, Oct. 1943, pp. 1–2.
12. A. TEN DAM, Stratigraphie, sedimentatie en micropaleontologie, Versl. Bijeenk. Micropal., no. 5, June, 1944, p. 1–3.
13. A. TEN DAM, Onder-Lias in de proefboring T. der ROvD op grond van foraminiferen, Geol. & Mijnbouw, T. 6, no. 1–2, pp. 14, 1944.
14. A. TEN DAM, Oude en nieuwe boringen in het Plio-Plistoceen van Nederland, no. 1, Geol. & Mijnbouw, T. 6, no. 5–6, pp. 45, 1944.
15. A. TEN DAM, Een nieuwe soort van het geslacht *Polymorphina* D'Orb., Geol. & Mijnbouw, T. 6, no. 5–6, pp. 44, 1944.
16. A. TEN DAM, La Stratigraphie et la microfaune du Tertiaire des Pays-Bas, Comptes Rendus de la Soc. Géol. de Fr., 1944, pp. 81–83.
17. A. TEN DAM, Les microfaunes de l'Albien des Pays-Bas comparées avec les faunes contemporaines du NW de l'Europe, Soc. Géol. de Fr., Comptes Rendus, 1944, pp. 105–107.
18. A. TEN DAM, Un coup d'oeil sur la structure du Bassin éocène des Pays-Bas, Soc. Geol. de France, Comptes Rendus, 1944, pp. 128–130.
19. A. TEN DAM and E. SCHIJFSMA, Note sur les genres foraminifères *Gyroidina* D'Orbigny et *Valvulineria* Cushman, Comptes Rendus de la Soc. G ol. de Fr., 1944, pp. 143–144.
20. A. TEN DAM, Bijdrage tot de kennis van het Tertiaire in oostelijk Nederland, Verh. Geol. Mijnbouw. Gen., T. 14, pp. 135–146, 1944.
21. A. TEN DAM, Die stratigraphische Gliederung des niederländischen Paläozäns und Eozäns nach Foraminiferen, Med. Geol. Stichting, Serie C. V. no. 3, pp. 1–142, 6 pl., 1944.

II

Published by students of the State University of Utrecht.

22. D. G. MONTAGNE, Geologie und Paleontologie der Umgebung von Sestanovac, Dalmatien, Diss. Utrecht, 1941, pp. 1–93, 8 pl.
23. J. F. C. DE WITT PUYT, Geologische und paleontologisch Beschreibung der Umgebung von Ljubuski, Hercegovina, Diss. Utrecht 1941, pp. 1–99, 5 pl.
24. J. VAN SOEST, Geologie und Paleontologie des zentralen Biokovo, Dalmatien, Diss. Utrecht 1942, pp. 1–42, 5 pl.
25. A. TH. C. RUTGERS, Geologie und Paleontologie des SO Teiles des Biokovo und seines Hinterlandes, Dalmatien, Diss. Utrecht, 1942, pp. 1–43, pl. 1–4.
26. A. VAN WESSEM, Geology and Paleontology of central Camaguye, Cuba, Diss. Utrecht, 1943, pp. 1–88, 3 pl.
27. F. G. KEIJZER, Outline of the Geology of the Eastern part of the Province of Oriente, Cuba, Diss. Utrecht, 1945, pp. 1–216, 11 pl.
28. M. G. RUTTEN, A synopsis of the Orbitoididae, Geol. & Mijnb., T. 3, no. 2, pp. 34–62, 1941.

29. J. P. VAN DER SLUIS and D. R. DE VLETTER, Young Tertiary smaller Foraminifera from the neighbourhood of Ngimbang, East Java, Proc. Ak. Wetensch., T. XLV, no. 10, 1942, pp. 1010–1015.
30. F. G. KEIJZER, An addition to Smaller foraminifera from the lower Oligocene of Cuba, Proc. Ned. Ak. Wetensch., T. XLV, no. 6, 1942, pp. 607–608.
31. F. G. KEIJZER, Eine neue eozäne Foraminiferengattung aus Dalmatien, Proc. Ned. Ak. Wetensch., T. XLIV, no. 8, 1941, pp. 1006–1007.
32. R. C. VAN BELLEN, Some Eocene Foraminifera from the neighbourhood of Ricice near Imotski, E. Dalmatia, Yugoslavia, Proc. Ned. Ak. Wetensch., T. XLIV, no. 8, pp. 996–1003, 1 pl., 1941.
33. R. C. VAN BELLEN, J. F. C. DE WITT PUYT, A. C. RUTGERS and J. VAN SOEST, Smaller Foraminifera from the Lower Oligocene of Cuba, Proc. Ned. Ak. Wetensch., T. XLIV, no. 9, pp. 1140–1146, 1 pl. 1941.

III

Published by members of the University of Leyden.

34. L. U. DE SITTER, Faciesanalyse, Geol. en Mijnbouw, T. 3, no. 8, pp. 225–237, 1941.
35. G. A. DE NEVE, Quelques remarques sur les Camerinidae et sur la structure interne de *Camerina orbignii* et de *Camerina memmelensis*, Verh. Geol. Mijnbouw. Gen., T. XIV, pp. 347–360, 1944.

IV

Published by other institutions.

36. J. DUFOUR, Eenige opmerkingen uit de practijk van een micropalaeontoloog, Geol. & Mijnbouw, T. 5, no. 9–10, 1943, pp. 68–74.

1. Describes 3 species, 1 new: *Darbyella nitida.*
2. Describes 1 species.
3. Describes 1 new species: *Nonion granulosum.*
4. Describes 3 species, 2 new: *Asterigerina frankei* and *Asterigerina staeschei.*
5. Describes 1 new species: *Uvigerina hosiusi.*
6. Describes 1 species.
7. Describes 95 species, 8 new.
8. Describes 168 species, 10 new.
15. Describes 1 new species: *Polymorphina striatula.*
21. Describes 170 species, 32 new.
22. Describes 58 species, 5 new.
23. Describes 72 species, 8 new and 1 new genus.
24. Describes 18 species, 6 new and 1 new genus.
25. Describes 34 species, 4 new.
26. Describes 60 species, 11 new.
27. Describes 95 species, 36 new, 4 new genera and 2 new subgenera.
28. Describes 14 genera and 10 subgenera.
29. Describes 14 species, 6 new.
30. Describes 1 new variety.
32. Describes 35 species, 7 new and 1 new genus.
32. Describes 1 new species and 1 new genus.
33. Describes 32 species, 11 new.

New varieties are included in number of new species.

From 1940 to 1945, inclusive, 152 new species and varieties, 8 new genera and 2 new subgenera were described in the Netherlands.

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 2, PP. 186–192, MARCH 1946

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